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QUARTERLY JOURNAL

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Suggestions as to the Methods of determining the Influence of Springs on the Temperature of a River, as illustrated by the Thames and its Tributaries.

BY H. B. GUPPY, M.B.

(Communicated by F. C. BAYARD, LL.M., F.R.Met.Soc.)

[Received November 1st.—Read November 21st, 1894.]

SOME of the small tributaries of the Thames, like the Malden River[1] and the Wandle, which are mainly fed by head-springs appearing at the surface, afford convenient opportunities for observing the influence of springs on river temperature. In suggesting the following methods of investigation, I would remark that our acquaintance with the thermal economy of rivers, though much increased by Dr. Förster's recent admirable memoir,[2] is not yet sufficiently exact to enable us to assign its true value to each of the lines of inquiry indicated below. Other better plans will doubtless present them-

[1] Also known as the Ewell River and the Hogsmill.

[2] "Die Temperatur fliessender Gewässer Mitteleuropas" (*Geographische Abhandlungen.* Wien: band V., heft 4, 1894).

selves to the minds of some, and it is probable that novel means will be dis closed in the course of each investigation.

(A.) *By a comparison of the curves of the monthly means of the tempera tures of the air and of the water for the river under observation with those o a river beyond the controlling influence of springs.*

I assume for the rivers of this country, that is to say for rivers very smal in size when compared with many continental rivers, that the limits of th control of the springs are passed when the curve of the water temperatur is above that of the air all through the year, the difference being greatest i summer, when it varies usually between 2° and 4; and least in winter, whe the curves are only 1° or so apart. This is true not only for the Thames a Greenwich within tidal influence,[1] but it also applies to the same river a Kingston beyond the reach of the tides;[2] and it is true as well for th more important of its tributaries at their mouths, if the Cherwell at Oxford is a typical instance.[3] It is the general character of the "Flachlandflüsse" of Dr. Förster, rivers of this class being defined by him as warmer than th air all through the year.

When, therefore, in the case of any of the Thames tributaries we find a marked departure from this rule, we must look for the disturbing cause; an if, as will generally happen, we can exclude those connected with a mountai course or an origin in a lake or a temporary disappearance under ground, w must look to the springs for an explanation. Thus by comparing the accom panying charts of the curves of the air and water temperatures for th Cherwell at Oxford and the Kennet at Marlborough, both of them tributarie of the Thames, we perceive that the Cherwell at its mouth has the therma regime of a river of the type above referred to, whilst the Kennet 10 mile from its source exhibits curves of a different type. The Cherwell is warme than the air throughout the year, a character that would have been mor strikingly illustrated in the diagram if the observations had been mad during the hour preceding noon, the time of mean temperature. On th other hand, the Kennet, during the summer half of the year, is a great dea cooler than the air. The Kennet at Marlborough is in fact an example o the "Quellflüsse" of Dr. Förster, or, in other words, it is largely con trolled by the springs. It finds its representative in a tributary of th Danube, the Ach, at Memmingen, the data for which, together with a chart o the curves, are to be found in Dr. Förster's monograph.

(B.) *By a comparison of the range of the monthly means*[4] *of the tempera*

[1] Sir G. B. Airy in *Proc. Roy. Soc.* Lond. Vol. 34. These well known observation covered a period of 33 years.

[2] From the writer's unpublished observations, which were continued for two years.

[3] Mr. Chapman's series of ten years' observations, on the Cherwell, *Brit. Ass. Rep* 1891.

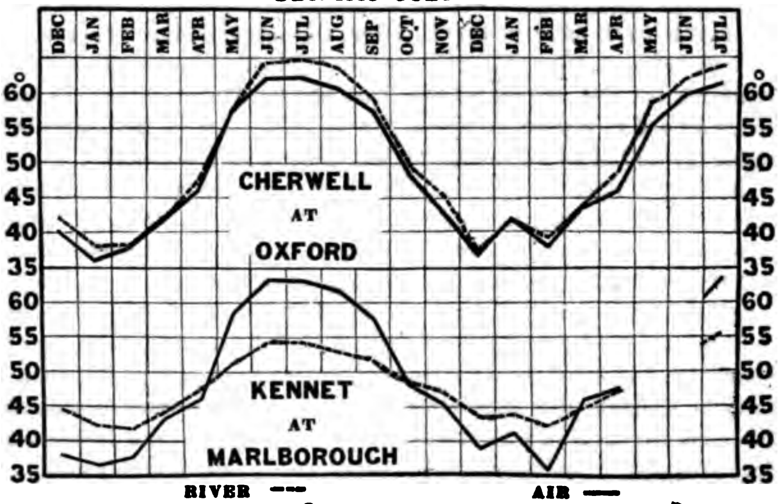
[4] The range of the monthly means during a series of years is not the differenc between the months with the highest and lowest averages; but it is greater than this as the hottest and coldest months vary considerably. It is estimated from the aggre gate of all the ranges. Calculated thus, it is 28°·9 instead of 26°·3 for the Thames a Greenwich (33 years), and 28°·8 instead of 26°·8 for the Cherwell at Oxford (10 years)

ture of the river under investigation with that of a river beyond the control of the springs.

This method is founded on the principle that the range would be very small at the sources, and would increase with distance from the springs as far as the limit of their influence. At the sources the range would be probably 5° or 6°. When the river reaches that part of its course where it passes from under the control of its springs and becomes subject to the agencies affecting atmospheric temperature, the range of the monthly means in this

RIVER & AIR TEMPERATURES

DEC. 1888 - JULY 1890



RIVER --- AIR —

RIVERS OBSERVED AT 9 A.M. AIR TEMP. AT MARLBOROUGH 9 A.M.
AIR TEMP. AT OXFORD IS MEAN OF MAX. & MIN.

country would be between 25° and 30°. The Thames and its tributaries are well fitted for the application of this method. Mr. Bayard's observations on the Wandle springs[1] enable us to place the range of this small river at its sources at about 6°,[2] whilst the Cherwell at Oxford ranges about 29°, the Thames at Kingston about 30°, and at Greenwich about 29°.[3] These data approximately determine the limits of the possible range of water temperature for the Thames and its tributaries. When, therefore, as in the case of

[1] Some of the observations were made on springs at their exits, and others on spring-fed pools, so that the results are of a varied character, the ranges of the monthly means differing greatly, the smallest being under 1° and the largest as much as 17°.

[2] The range of the combined monthly means of the ten springs observed by Mr. Bayard during the year commencing with November 1888 is 47°·6 – 53°·7. This gentleman tells me that on any given day the mean of the ten springs was very near the temperature of the Wandle at its commencement. His observations, which extended over 15 months, are referred to in Dr. Mill's *British Association Report*, 1891. They are given in full by Mr. Cushing in *Proc. Croydon Nat. Hist. Club* for 1891.

[3] It should be noted that the observations at Oxford, Kingston, and Greenwich cover periods widely different in extent (*vide supra*).

the Kennet at Marlborough,[1] 10 miles from its sources, we find a tribut with a range of only about 12°, we may, if other influences are exclud attribute this result to the springs.

Now the Kennet runs a course of about 50 statute miles before it joins t Thames; and the question to be answered is, how far down the stream a its waters under the controlling influence of the springs. We have se that spring influence is predominant 10 miles from the sources; but sir the Cherwell is not under the control of the springs at its junction with t Thames after a course of nearly 40 miles, we may infer that the Kennet, lo before it joins the Thames at Reading, will be, like the Cherwell at Oxfo freed from their sway. We can therefore surmise that a tributary of t Thames 40 to 50 miles in length throws off the equalising influence of t springs before it joins the main stream. I will subsequently show th smaller tributaries, like the Malden River and the Wandle, which are resp tively six and nine miles in length, and are chiefly fed by head-springs, a under the control of the springs for the whole of their courses.

Beverley Brook, another affluent of the Thames, about nine miles length, is far less under the influence of head-springs than the two rivers ju mentioned. In its upper course it becomes very low in summer; and fact when it reaches the outskirts of Wimbledon Common, about five mi from its mouth, its temperature is regulated by the atmospheric agencies, that, judging from a few observations which I have made, the range of monthly means would there be quite 30°. As it flows past the Common a through Kingston Vale it receives a considerable accession of water fr perennial rills and subsoil oozings, so that its temperature becomes the very irregular. But their effect is evanescent; and probably enough, summer, its temperature at the mouth will be as high as, or higher than, t temperature of the Thames.

The Mole, a Thames tributary, about 25 miles in length, would appe from some observations which I have made in different seasons of the yea to exhibit a range of monthly mean temperatures 2° or 3° less than that the main river. The principal difference occurs in summer, when, near i mouth, it is usually 2° or 3° cooler than the Thames. Now it is at th season in particular that the Mole pursues a subterranean course for a mi or two under Box Hill,[2] some 17 miles along its banks from the mouth; a it is to this circumstance rather than to the effect of the head-springs that owes its comparative coolness on nearing the Thames.

[1] The range of the monthly means of the Kennet at Marlborough in 1889 was 41 (February) to 54°·3 (June), or 12°·5. The Cherwell at Oxford in the same year ha range of 27°·4, the difference between 37°·3 in December and 64°·7 in July. The servations for both rivers were made at 9 a.m. Those for the Kennet were undertak by Messrs. W. and H. Maurice, and the results are given in Dr. Mill's *British Associ tion Report*, 1891. Other rivers dealt with in this report, such as the Stour at Cant bury, afford evidence of spring control in the limited range of the monthly means.

[2] It would be of interest to determine the difference between the temperature of t river as it disappears in the "swallows" and its temperature when it reappears.

Looking at these data relating to six Thames tributaries, the Cherwell, the Kennet, the Mole, the Malden River, Beverley Brook, and the Wandle, I should consider that affluents mainly fed by head-springs and up to 10 miles in length never get beyond the control of the temperature of the springs; that those 25 miles long are able to free themselves from their sway; and that rivers 40 to 50 miles in length are not affected by the springs beyond the upper half of their course.

The range of the monthly means for any of our rivers may be readily obtained[1] by taking observations every other day in December, January, and February, and in June, July, and August, at 11 a.m. in summer and at noon in winter.

(C.) *By a comparison of the range of the monthly means of the river temperature with that of the air in the shade.*

A river of the flat country in England, when free from disturbing influences, will be near the temperature of the air in winter, but in summer it will be usually from 2° to 4° warmer than the air, so that the range of the monthly means for the river will be rather greater than that for the air. Therefore, when we find the water-range markedly less, we must look out for the disturbing cause; and if we are able to exclude those arising from a mountain or a subterranean course or from an origin in a lake, we are at liberty to consider such an effect to be due to the controlling influence of springs. This method is, of course, included in that relating to the comparisons of the curves of the air and water temperatures, the method A of this paper; but I have given it a separate place because observations need only be taken in the winter and summer months named under method B. As it has been already illustrated, I shall merely give emphasis to its utility by directing attention to the diagrams for the Cherwell and the Kennet.

(D.) *By comparing the daily range of water temperature at different stations along a river's course.*

This would be almost nothing at the springs, and would gradually increase with distance run until the limit of spring influence is passed, when it would become more or less stable. Such is the behaviour of spring-brooks and perennial rills,[2] and we cannot doubt also of several of the tributaries of the Thames. This method to be persistently carried out would involve considerable trouble; but employed in a limited fashion, it would be a valuable preliminary test. Only four or five sets of observations would then be required, and in rivers where springs control the temperature for several miles, the stations should be a mile or so apart; but in streams or small rivers, where the observer can within an hour-and-a-half visit all the stations, one person can efficiently carry out the scheme, since in that interval the water temperature would but slightly change. Fine weather should be selected, and each set of observations ought to consist of three in the 24 hours, namely, during

[1] This subject is dealt with by the author in *Proc. Roy. Phys. Soc. Edin.* January 1894.

[2] I have discussed this matter in *Science Gossip* for October 1894.

the hour following sunrise, between 3 and 4 p.m., and at the following sunrise; or the series could begin in the afternoon. The corresponding minimum and maximum temperatures of the air in the shade should be at the same time noted; but, in the absence of self-recording instruments, observations with an ordinary thermometer at sunrise and at 2 p.m. would give approximate results.

I may remark that this method is by no means the simple plan it at first appears to be. Hot days and cool nights, with the consequent great diurnal range of air temperature, afford the best conditions, and the temperature of the river at its sources should be about that of the daily mean of the air. For instance, with the air ranging between 40° and 65° and the river at its sources about 52°; circumstances we might expect to find early in May or early in October; we ought to get good results. In the middle of summer, when the air minimum and the temperature of the springs would be near rogether, the observations would have to be restricted to the determination of one of the elements of the daily range, namely the rise.[1]

(E.) *By a comparison of sunrise observations made at different stations along the river's course.*

In settled weather during the warm half of the year an ordinary river uncontrolled by springs is at sunrise several degrees warmer than the air. This is a well-known feature of river temperature, to which I have referred in the paper before quoted. For instance, in the case of the Thames at Kingston, I have found the difference to be frequently over 10°. At this hour, however, the temperature of a river under the influence of springs would be much nearer the air minimum and might even be lower. In winter the effect of springs would be to increase greatly the usual excess of the temperature of the river over that of the air. Four or five sets of observations, a week or so apart, would answer every purpose of a preliminary test; and in rivers where springs extend their influence for several miles, simultaneous observations should be made by different observers a mile or two apart; but in ordinary streams one observer could do it all in an hour's walk from the springs.

(F.) *By a comparison of observations made at different stations along the river's course at the hour of maximum temperature, 2 p.m. in winter and between 3 and 4 p.m. in summer.*

This method should be carried out in the manner just mentioned under method (E), namely, by simultaneous observations at stations a mile or so apart for rivers like the Kennet or the Wandle, or by a single observer in the case of brooks or streams. A hot summer afternoon and a frosty day in winter should be chosen for the purpose, the seasons of spring and autumn

[1] The daily range of river temperature and the time of observation are discussed in my paper in *Proc. Roy. Phys. Soc. Edin*, Jan. 1894. The matter is ably handled by Dr. Förster in *Geograph. Abhandl.*, Wien, band V. heft 4, 1894. The mean daily range of the Thames at Greenwich is 2°·1, and at Kingston about 1°·5. In tributaries of the Thames beyond the control of the springs it would be probably not under 4° for the year's average, and as much as 6° in July, and as little as 3° in winter.

being less suitable, since at those periods the temperatures of a river within and beyond the control of the springs are not far removed. It is scarcely necessary to point out that in winter the river temperature would fall with distance from the springs; whilst in summer it would increase, the change proceeding in either case until a constant temperature betokens the limit of their influence.

(G.) *By the comparison of the results obtained from a single series of observations made in one day along the whole course of a small tributary like the Wandle, or along the upper course of a larger tributary as the Kennet.*

This plan, which can be accomplished in a day's walk, is a rough and ready method that might be useful in first examining a river with a view to a more systematic inquiry. The seasons when the constant temperature of the river beyond the control of the springs is farthest apart from the temperature of the sources, namely in the middle of winter and the middle of summer, should be selected; and the main stream, in this case the Thames, will afford a valuable means of comparison. I have put this method into practice in the instances of the Wandle and the Malden River, the results being given in Tables I. and II. For the observations on the Wandle springs I am entirely indebted to the courtesy of Mr. Bayard, who took me to the various localities.

With regard to the Wandle series, the coolness of the river, relatively to the Thames, along the whole of its course is apparent. The fall of temperature in the middle third of the series is due probably to those observations being made in the forenoon, while those of the upper third were made in the afternoon. The rise of the temperature near the mouth is doubtless the effect of the accumulation of the water above the dam, whereby an element of pond *régime* is introduced, namely a higher plane of temperature. The low atmospheric temperature of the previous night introduced another disturbing cause, as it would affect the Wandle more than the Thames; but judging from my observations on the diurnal range of the Mole and the Malden River, this would not account for more than 2° of the difference. After allowing, however, for a rise in the temperature of the Wandle as the day progressed, and for a slight increase in that of the Thames, I arrive at the conclusion that the Wandle during the afternoon would not have had a higher temperature than 56° in any part of its course, whilst the Thames temperature would have been about 61°. By stating it in this way the disturbing causes are eliminated to a great extent, since the elevation of temperature due to the dam at the mouth is no doubt counterbalanced by the greater nocturnal cooling of the Wandle as compared with the Thames. The most satisfactory plan of carrying out this series of observations in summer would be to leave Hackbridge at 1 p.m., arriving at the Thames not later than 6 p.m. By this means we should be able to disregard the uncertain element of the daily rise of temperature. We should be observing the Wandle during the heat of the afternoon, and the Thames on our arrival would be still at its maximum. In winter the method would have to be adapted to the shortness of the day; but the daily rise of river temperature would on a cold frosty day be almost absent.

TABLE I.—TEMPERATURE OF THE WANDLE RIVER ON SEPTEMBER 4TH, 1894.

Average rate of current 1 foot per second. Usual depth 2 to 3 feet. Average width 50 or 60 feet. Weather fairly sunny to 2 p.m. Air in the shade at Kingston 41°–61°. The Wandle proper begins a few hundred yards above Hackbridge at the junction of the Croydon and Carshalton branches.

Time.	River.	Locality.	Distance from Mouth.	Temperature.
			Miles.	°
7.15 a.m.	Thames	Kingston (above tidal influence)	..	59·4
8.30 „	Thames	Wandsworth Pier (tide ebbing)	..	60·6
9.0 „	Wandle	Dam close to mouth	¼	54·8
9.15 „	„	High Street, Wandsworth	½	54·4
9.45 „	„	Duntshill, below railway	1¼	52·8
10.15 „	„	Plough Lane, Garratt	2¼	52·8
11.0 „	„	Merton Abbey	3¼	52·7
11.15 „	„	About 500 yards above Merton Abbey, by roadside	4	52·7
12.30 p.m.	„	Bridge, Mitcham, to Sutton Road, near Ravensbury Park	5¼	53·7
1.0 „	„	Beddington Corner	6¼	54·0
1.45 „	„	Hackbridge, 300 yards below junction of the two head branches	7	53·5
2.0 „	Carshalton Branch of the Wandle	About 300 yards above junction, below railway	7½	54·9
2.45 „	Croydon Branch of the Wandle	About a third of a mile above junction	7½	54·0
4.0–4.30	Springs of the Carshalton Branch of the Wandle	Park Wall, Phillpott's Corner	..	58·0
		Park Wall, Haydon's Corner	..	55·8
		Lower Pond Steps	8 to 8½	51·1
		Waterhouse Pool	..	50·8
		Upper Pond, C. House Stream	..	52·2
4.45–5.15	Springs of the Croydon Branch of the Wandle	Wallington Corner	..	52·6
		Smee's Mill I.	..	54·8
		Smee's Mill II.	8 to 9	52·2
		Ellis Road Stream	..	53·4
		Ellis Stream	..	51·8

NOTE.—The mean of the temperature of the springs is 53°·3. In several cases the temperature is not that of the spring at its exit, but of the spring water issuing from a pool. Although the initial temperature of the Wandle is considerably affected by the artificial pools and ponds at the sources, it is probable that without man's aid this river would mainly rise from spring-fed pools.

Whilst the Wandle is fed by its head-springs, and does not increase much in bulk on its way to the Thames, the Malden River, which is scarcely half its size, is joined by three lesser tributaries in its course, and gains considerably in dimensions as it approaches the Thames. For these reasons the Wandle is far better suited for this investigation. My observations on the Malden River were confined to the main stream, and to one of the principal sources in the midst of the village of Ewell. Of the temperatures of the tributaries I learned nothing, except in so far as they found expression in that of the main stream. The series, however, plainly shows that the Malden River is able to carry the cool waters of its springs into the Thames. It rarely does so, however, to any considerable extent, since by the intervention of a mill it expands into a deep pool at its mouth, the surface waters of which are readily heated. The Malden River is in fact a

TABLE II.—TEMPERATURE OF THE MALDEN RIVER (ALSO KNOWN AS THE EWELL RIVER AND THE HOGSMILL), ON AUGUST 30TH, 1894.

Average rate of current 1 foot in two seconds. Usual depth 1 to 2 feet. Average width 20 feet. Hot sunny weather. Air in the shade 51°–73°.

Time.	River.	Locality.	Distance from Mouth.	Temperature.
			Miles.	°
2.15 p.m.	Ewell Springs	Ewell village	6	51·5
	,, ,,	Exit from first pool	5⅞	53·5
	,, ,,	Exit from second pool	5¾	57·5
3.0 ,,	Malden River	Railway arch	5½	58·0
3.45 ,,	,, ,,	Roxley Farm	4½	58·5
4.45 ,,	,, ,,	Surbiton to Ewell road	3¾	59·0
4.15 ,,	,, ,,	Malden Church	3	59·3
5.30 ,,	,, ,,	Quarter mile above South-Western Railway	1¾	59·8
6.0 ,,	,, ,,	Oil Mill Lane, Kingston	½	60·6
6.15 ,,	Thames	Kingston	..	64·6

much afflicted stream in this respect, even more so than the Wandle. It is to be noted in my observations that the water gained 6° in temperature by passing through the broad shallow pools in connection with the mills in the village of Ewell. If allowed to run free from its springs to the Thames, this tributary would doubtless reach that river 8°, instead of, as on this occasion, 4° cooler than the Thames. I have already remarked that the temperature of the head waters of the Wandle is influenced by ponds at the sources.

(H.) *By determining the distance from its sources at which the river begins to freeze.*

Here observation can be supplemented by the experience of residents and from the local histories. The old county histories, whilst noting the inability of the Wandle to freeze in the upper part of its course, attribute it to the influence of the mills. Though the mills can afford no explanation, their records may be worth while examining. I have been informed that the Malden River, which is stated never to freeze at Roxley Farm a mile-and-a-half from its sources, rarely freezes at Malden, a mile-and-a-half lower down, and then only at the edges.

I will conclude this paper with some remarks on the thermometer used and on the mode of investigation. The instrument I employed was a bath thermometer of the Admiralty pattern, such as is used on board Her Majesty's ships for sea temperatures. It was supplied to me by Messrs. Negretti and Zambra, accompanied by a Kew certificate, and is graduated to degrees on the stem. Not every bath thermometer will stand the test of an ordinary sunrise observation of the temperature of a river. Here the instrument has often to be pulled up 6 or 8 feet through air 10° or 12° cooler than the water, with perhaps a fresh breeze blowing. To get a correct result under such circumstances, the bulb must be relatively small and deeply set

and the pocket capacious; and before finally selecting a thermometer it should be put to this test by an experiment at home, instruments with large bulbs and small shallow pockets are liable to fail.

It will be best, as far as possible, to make all the observations in mid-stream, and at a depth of from 18 inches to 2 feet, though, as a matter of fact, these precautions are really necessary only in the case of very sluggish rivers. It has been established by Dr. Förster and the present writer that rivers running free, with a current, say of a mile an hour, exhibit nearly the same temperature in depth and breadth. The matter is more often one of access and convenience; and for our own rivers, usually, it should be remarked, of a very sluggish type, marginal observations are only reliable when the water is moving well with the current. Slack waters in shallow places heat up rapidly, and back-waters, except where the depth is considerable, should be avoided. In case of doubt, an observer could, on a hot summer day, readily find a suitable observing station by the aid of his thermometer. The time of immersion, which varies for each instrument, should be ascertained by experiment, some thermometers requiring as much as five minutes, others as little as two or three minutes. For determining the daily range the employment of continuously immersed maximum and minimum thermometers would, in a river like the Wandle, be impracticable, except in private waters. My experience of them has been very slight.

DISCUSSION.

THE PRESIDENT (Mr. R. INWARDS) said that this paper was rather one of suggestions for future observations than a statement of results of any investigation already completed. He thought that exceptional facilities for making observations of river temperatures with respect to springs were afforded after a long drought, as then the flow would almost entirely consist of spring water. The temperatures could be corrected by comparison with those of pond water in the vicinity.

Dr. R. BARNES pointed out that the author had omitted to state at what depth below the surface of the water the temperatures were observed, as on a hot summer day the surface temperature of a stream was commonly higher than that at a depth of 3 or 4 feet. Rain, especially heavy rain, exercised an influence upon the temperature of streams by causing a layer of warmer water to accumulate on the surface. The influence of snow must also be noted. It was important, too, that the depth of the water should be noted, shallow streams being subject to greater fluctuations of temperature than those in which the water was deep.

Mr. G. CHATTERTON thought that the temperatures given in Table I. were of very little value, as considerable quantities of purified sewage from Wimbledon and Croydon were discharged daily into the river Wandle, and this sewage being at a much higher temperature than the river water, would quite mask the real temperature of the natural river.

Mr. R. W. P. BIRCH said that the paper put forward so many views that it required careful perusal before discussion, but he thought all that could be said at present concerning the temperature of rivers was that it was most equable near the springs which form them.

Mr. W. B. TRIPP remarked that it would be interesting if observations of the temperature of the dew point were taken in connection with the surface temperature of rivers. He had noticed in hot climates that the temperature of the water was at times below the dew point temperature.

Mr. H. SOUTHALL said that exposed rocks in a shallow stream considerably influenced the temperature of the water, as in hot weather the rocks became greatly heated. The River Wye, owing to the influence of rocks, rose to a very

high temperature in hot weather, and he had known the water to reach a temperature of 81°. It appeared desirable to know the character of a river as regarded its surroundings when considering the temperature of its waters.

NOTE ON SOME EFFECTS OF THE GALE IN THE HIGHLANDS OF SCOTLAND ON NOVEMBER 17th AND 18th, 1893.

By ERIC STUART BRUCE, M.A., F.R.Met.Soc.

[Received October 4th.—Read November 21st, 1894.]

While spending my summer holidays in Perthshire, I had occasion to witness the disastrous effects of the great gale of November 1893 upon the trees in some parts of that county. The storm has been fully chronicled in the paper read before the Society by Mr. C. Harding on December 20th, 1893.[1] It may, however, be of interest to show some photographs descriptive of the destruction of trees in Perthshire, especially in the valley of the Tummel, where I believe the storm wreaked its greatest violence. I am enabled to show these photographs by the kindness of some of the landed proprietors in the district affected, who gave me facilities for obtaining them. Most of the ravages depicted in the photographs were done on the night of November 17th and early morning of the 18th. [These photographs were shown to the Meeting, but are not reproduced here.]

There could be no better example of the violence of the gale than the immediate surroundings of Lude House, Blair Athole, the residence of Mr. W. McInroy, once situated in picturesque woods, but now amidst a scene of desolation. It is no exaggeration to say that there is not a single tree in the picture that is whole. Passing to another part of the same property, the trunk shown in the photograph has been peculiarly doubled up by the wind. Some one has well described the gale as having blown the trees to pieces, and this is a very true description of its effects on several trees which I have seen, whose trunks are split and shivered as if a charge of dynamite had been exploded in their midst.

Dr. Rankin, in his letter to the *Scotsman*,[2] describes a curious incident illustrative of the force of the wind. "A slate was carried 80 yards from the roof of a joiner's house with such violence that it cut through the stem of a young fir tree and fell at the foot of it."

The view also shows the partly demolished roof of the shed. Other photographs, also on the same estate, represent the downfall and wreckage of several fine trees.

[1] *Quarterly Journal*, Vol. XX., p. 43.
[2] *Scotsman*, Nov. 22nd and 25th, 1893.

The beautiful grounds of the Athole Hydropathic Establishment at Pitlochry suffered much from the gale. By the kindness of Mr. Macdonald, the proprietor, I can show some photographs taken the morning after the damage was done. 1. The lawn tennis ground, showing how the tree with the lawn tennis notice attached to it carried the circular seat with it. 2. A whole row of fir trees fallen along the side of a path. 3. The downfall of another tree with its circular seat. 4. Large fallen tree. 5. Mass of tree debris. 6. The effects of the gale looking towards the steps on the path from the hydropathic establishment.

Many of the trees blown down were found lying in different directions, thus pointing out that the direction of the wind changed during the violence of the storm. Messrs. Omond and Rankin have kindly supplied me with the observations at the Ben Nevis observatory as to direction, force, and velocity of the wind from 6 p.m. on November 17th to 6 p.m. on the 18th. Though the observatory is not very near the district depicted in the photographs, and the observations are taken at a considerable elevation, it may be of interest to refer to them.

The figures indicate that the direction of the wind was very variable during the early morning hours of November 18th. At 1 a.m. it was North-east ; at 2 a.m. North ; at 3 a.m. variable ; at 4 a.m. variable ; at 5 a.m. East-south-east ; and at 6 a.m. North-east again. So it is not a matter of surprise that trees were found lying in different directions in several parts of the highlands. It is possible that in some cases the varying directions may have been due to the "rebounding" of the wind from hill-sides, as suggested by Dr. Rankin in his letter referred to above. A change of direction was also noticed in the woods of Drumlanrig after the gale of January 26th, 1884. The Ben Nevis observations also show the squally nature of the gale making it impossible to assign any one value to the force. For instance, the velocity in miles per hour for 9 p.m. November 17th is put down as 31 to 85 ; for 10 p.m., 39 to 85 ; 11 p.m., 21 to 73 ; for midnight, 21 to 85.

It is highly creditable to the enterprise and skill of Mr. Macdonald that some 800 of the trees blown down on his property have been replanted, and, being temporarily supported by galvanised wire, are now thriving. It is a pity that a similar course of action was not taken by some of the other landed proprietors, especially in such spots as the pass of Killicrankie. It is no exaggeration to say that during the gale whole woods were swept away, leaving only the carcases of trees. Such was the fate of the wood at Strathgarry, Killicrankie. (Photograph shown.) At the celebrated pass of Killicrankie the destruction is not so formidable as in some other parts, but still much of the summer beauty of the pass is now marred by the ugly gaps in what was before an unbroken mass of verdure (photograph shown).

In looking at the partial disfiguration of this historic spot, I was forcibly reminded of a similar catastrophe, in the classic broad walk at Christ Church College, Oxford, some 15 years ago. I obtained some photographs descriptive of the damage at the time, and, in conclusion, it may be of interest to show them to the Meeting. I am unable to remember the exact date of the

storm. Mr. Stone, of the Radcliffe Observatory at Oxford, writes to me that he is under the impression that the date was October 14th, 1881, when the highest velocity recorded was 68 miles, but I have reason to believe it was an earlier date than this.

DISCUSSION.

Mr. C. HARDING said that it would be interesting to know in what general direction the trees lay on the ground. Judging by the movements of the depression which occasioned the gale, he presumed that it was the Northerly wind that caused the most destruction. The greatest hourly velocity (96 miles) recorded by the anemometer at Deerness, Orkney, during this gale was the highest ever known.

Mr. H. HARRIES said he had been informed by a gentleman who had been visiting the eastern districts of Scotland that the destruction of trees on that side was immense, but what was locally observed as the curious feature of the event was that the trees were laid from the North-westward, a very unusual direction for heavy gales in that district, being generally Southerly or South-easterly. It was, therefore, thought that the damage was due not so much to the strength of the wind as to the fact that the trees were struck on their weakest side. It will be remembered that this gale, which was at first from the normal Southerly direction, suddenly burst from the North-west quarter when the centre of the disturbance began to move Southward along the east coast of Scotland.

Mr. R. COOKE remarked that he had once observed a curious effect of a gale in a hop garden, no poles being disturbed round the edges of the garden, while in the middle they were blown down in all directions. This was considered to be due to the undulatory motion of the gale, and may perhaps account for the curious effect of a storm in a forest, one tree being taken and another left.

HISTORY OF A WATERSPOUT.

By ALFRED B. WOLLASTON.

(Communicated by ROBERT H. SCOTT, F.R.S.)

[Received July 12th—Read November 21st, 1894.]

SOME years since (1840 or 1841), when senior officer of the watch on board a large East Indiaman (the *Vansittart*), then in the eastern part of the Bay of Bengal, I noticed a peculiar disturbance of the water, which had the appearance of being forced up in innumerable small jets, covering an area of fully 400 yards in diameter, through which we were slowly passing with a light steady breeze only sufficient to give the vessel steerage way. The sky was absolutely cloudless. These jets rapidly increased in number and force, throwing up vapour, like steam, and seeming to revolve and draw towards a centre. When this action had continued for a short time, and a dense column of steam was rising, a small cloud became visible immediately above; its centre reaching downwards. When the two columns united a

magnificent waterspout resulted, rapidly rotating. Dense clouds rapidly overshadowed us. Rain fell in torrents. The wind freshened for a short time and again fell light. In less than half an hour all symptoms of any disturbance had ceased.

One feature out of many others was, that the concentrating jets, although they had produced a pile of foam, did not immediately develop into a *visible* column. I venture the suggestion that, as with the cloud overhead, it was only by condensation of its circumfluent vapour that it became so. It was never so dense as to entirely obscure the horizon when viewed through a telescope. The interior seemed to be rising infinitely more rapidly than the exterior. Constant flashes of flame-like vapour were being violently whirled up.

I would mention that I know of one other instance of the sea being disturbed in a similar manner over a much larger area, but the jets did not gyrate and no waterspout resulted.

DISCUSSION.

Mr. R. J. Lecky, in a letter to Mr. Scott, said:—"Mr. Wollaston appears to be dubious as to the formation of this grand phenomenon. He suggests electricity, and so far, doubtless, he is right. I may, however, explain my views by an examination of this special case. The ship is, on a fine clear morning, in the eastern side of the Bay of Bengal (which in the rainy season is perhaps the wettest part of the globe), and with an upper atmosphere which, from the data you have kindly sent me, must have contained from eighty to ninety thousand tons of water, in solution, to each cube mile. An isolated mass of this atmosphere, many miles in extent, becomes electrified in a high state of tension, exactly as is the case in one of our common thunderstorms (the cloud formation being an after-consideration), and, in the same way, induces the contrary state in surface of the earth or sea: these two electric states approaching until the favourable place and time arrive for the discharge, when the upward current, meeting with resistance from the mobile sea surface, develops heat sufficient to cause the appearance of steam, which it carries with it as it ascends to join the other electric state. This latter descending, carries with it saturated atmosphere sufficient to form the small cloud, which is seen to meet the ascending current. The junction is then complete, condensation speedily follows, the black cloud is formed, and the descending electric current carries with it a dense column of rain, as a waterspout, confined to the comparatively small area of the point of discharge. The currents become mutually nullified, the actual column of water breaks up, and the discharge of rain becomes general. I alluded to our ordinary thunderstorms being produced in their early stages by similar causes to the above. When the electric influence is in a sufficient state of tension, the discharge is more acute, and when meeting resistance the heat, so instantaneously developed, produces those effects falsely attributed to the lightning flash, which itself is only an after result. Whirlwinds also are produced by the same cause, but the current is of much larger volume, and the intensity very much reduced. The mode by which these isolated masses of the upper atmosphere receive their charge of electricity is a difficult subject to put into simple form, but to those who have studied the action of the Leyden jar, or, better still, the coated sheet of glass (the same in principle), can easily understand how the electricity of the surface of the earth acts by induction on the upper atmosphere, producing the opposite state of electrical influence; and in this case the earth may, for the nonce, be considered as a grand electrical machine, and the dry lower atmosphere as the intervening di-electric."

Mr. R. H. Scott read the following notes on Waterspouts which had been extracted from unpublished ships' logs in the possession of the Meteorological Office;—

AUGUST 20th, 1855, *Crest of the Wave*, Captain John Steele.—At 7 a.m., when in lat. 35°·50′ N., long. 19°·42′ E., or 138 miles W. ¼ S. from Cape Matapan, passed under a waterspout. At 6 a.m. heavy squall-like cloud forming at south east and north-west, a waterspout forming at east end of South-east squall, and another at west end of North-west squall, both squalls closing upon the ship. Up to this time the weather had been clear, with an almost cloudless sky and light but steady wind from West-south-west. All studding sails had been set during the night. At 6.30 took in studding sails and all light sails, hauled up courses, and stood by topsail haulyards and jib down haul. Waterspout now near at hand direct ahead, and coming fast upon us. Let fly topsail haulyards, and had got the jib about half down when it struck us on the port bow, filling staysail and jib to starboard but pressing fore yard far aback. In another instant filling head yards and pressing main yard aback and again throwing main and mizen yards full and aback at the same instant, whirling along port side with a violent gust and round the stern with a loud noise, throwing water into the stern windows as it passed. A moment after there was a calm, then heavy gusts succeeded by a heavy squall and much rain from east-south-east.

"The waterspout waved and bent to the whirling wind, and in its action was like a huge transparent chimney in which the water, 'smoke like,' was curling its way to heaven. I had time to view it, and was much struck with the curling vapour rolling up its glass-like tube. I have heard it stated that anybody passing through a waterspout would burst it; this one had half its base acting upon my ship, but still remained perfect in form and action."

OCTOBER 26th, 1855. *Medway*, Captain J. B. Kennedy, lat. 6°·18′ N., long. 24°·21′ W.—9 a.m. saw a strange circular motion of the water close to us; it was like an eddy in a tide way, or like the motion of the water in a whirlwind; it was going very slowly to the north, in the teeth of a faint air from the Northward. When about a quarter of a mile from us it turned into a regular whirlwind. I could not perceive any motion in the clouds, nor any sign of wind near it. About a quarter of an hour after this the wind flew round to the South-south-east in a sharp squall, with heavy rain."

DECEMBER 10th, 1858. *Medway*, Captain J. B. Kennedy, lat. 6°·7′ N., long. 85°·40′ E.—Several waterspouts about. They make up on the surface of the water, like a whale blowing, and then connect themselves with a cloud (nimbus) above them, leaving a break between them.

Mr. A. B. WOLLASTON remarked that Capt. Steel's account referred to the ascending motion of the spout, which coincides with what he (Mr. Wollaston) had noted.

Capt. D. WILSON-BARKER said that the best waterspout he ever witnessed most certainly descended, but he did not wish to imply from this that it was always so.

Capt. A. S. THOMSON stated that all the waterspouts which he had seen had occurred with a very cloudy sky, and when a large amount of condensation was in progress. He did not think that electricity played any part in the production of these phenomena, but considered that they were due to rapid condensation. Capt. Thomson then gave a description of the various processes which, from careful observation of waterspouts on many occasions, he thought it was probable took place when a waterspout was formed.

The Report on Cloud Nomenclature, &c., presented to the International Meteorological Committee at Upsala, in August 1894.

By ROBERT H. SCOTT, M.A., F.R.S.,
Foreign Secretary.

[Read December 19th, 1894.]

The chief feature of the Upsala Meeting was the Report of the Committee appointed at Munich, to consider the question of the Cloud Atlas.

Of that Committee there were present at Upsala Prof. Hildebrandsson, Hofrath Dr. Hann, Prof. Mohn, Mr. A. Lawrence Rotch, and M. Teisserenc de Bort.

The following Members of the International Meteorological Committee were coopted with the Cloud Committee for the Meeting:—Prof. von Bezold, of Berlin, Director Billwiller, of Zürich, and Mr. Davis, of Cordoba.

In addition certain gentlemen present at Upsala were invited to join in the discussions, viz.:—Prof. Broounof, of Kieff, Dr. Fineman, and Dr. Hagström, of Upsala, Prof. Riggenbach, of Basle, Prof. Sprung, of Potsdam, and M. Weilbach, of Copenhagen.

The following are the Definitions and Instructions as finally adopted:—

The classification adopted is as follows:—

a. Separate or globular masses (most frequently seen in dry weather).

b. Forms which are widely extended, or completely cover the sky (in wet weather).

A. Upper Clouds, average altitude 9,000 m. (29,528 ft.).

a. 1. Cirrus.
b. 2. Cirro-stratus.

B. Intermediate Clouds, between 3,000 m. (9,842 ft.) and 7,000 m. (22,966 ft.).

a. { 3. Cirro-cumulus.
     4. Alto-cumulus.
b. 5. Alto-stratus.

C. Lower Clouds, between 1,000 m. (3,281 ft.) and 2,000 m. (6,562 ft.).

a. 6. Strato-cumulus.
b. 7. Nimbus.

D. Clouds of diurnal ascending Currents.

8. Cumulus; apex 1,800 m. (5,906 ft.); base 1,400 m. (4,593 ft.);
9. Cumulo-nimbus; apex 3,000 m. (9,842 ft.) to 5,000 m. (16,405 ft.); base 1,400 m. (4,593 ft.).

E. High Fogs, under 1,000 m. (3,281 ft.).

10. Stratus.

EXPLANATIONS.

1. CIRRUS (Ci.). *Detached clouds, delicate and fibrous looking, taking the form of feathers, generally of a white colour,* sometimes arranged in belts which cross a portion of the sky in "great circles," and, by an effect of perspective, converge towards one or two opposite points of the horizon (the Ci.-S. and the Ci-Cu. often contribute to the formation of these belts).

2. CIRRO-STRATUS (Ci-S.). *A thin, whitish sheet,* at times completely covering the sky and only giving it a whitish appearance (it is then sometimes called Cirro-nebula), or at others presenting, more or less distinctly, a formation like a tangled web. This sheet often produces halos around the sun and moon.

3. CIRRO-CUMULUS (Ci-Cu.). *Small globular masses or white flakes without shadows, or having very slight shadows, arranged in groups and often in lines.*

4. ALTO-CUMULUS (A.-Cu.). *Largish globular masses, white or greyish, partially shaded, arranged in groups or lines, and often so closely packed that their edges appear confused.* The detached masses are generally larger and more compact (changing to S-Cu.) at the centre of the group; at the margin they form into finer flakes (changing to Ci-Cu.). They often spread themselves out in lines in one or two directions.

5. ALTO-STRATUS (A-S.). *A thick sheet of a grey or bluish colour,* showing a brilliant patch in the neighbourhood of the sun or moon, and which, without causing halos, may give rise to coronæ. This form goes through all the changes like the Cirro-stratus, but by measurements made at Upsala, its altitude is one-half less.

6. STRATO-CUMULUS. (S-Cu.). *Lagre globular masses or rolls of dark cloud, frequently covering the whole sky, especially in winter,* and occasionally giving it a wavy appearance. The layer of Strato-cumulus is not, as a rule, very thick, and patches of blue sky are often visible through the intervening spaces. All sorts of transitions between this form and the Alto-cumulus are noticeable. It may be distinguished from Nimbus by its globular or rolled appearance, and also because it does not bring rain.

7. NIMBUS (N.). RAIN-CLOUD. *A thick layer of dark clouds, without shape and with ragged edge,* from which continued rain, or snow generally falls. Through the openings in these clouds an upper layer of Cirro-stratus or Alto-stratus may almost invariably be seen. If the layer of Nimbus separates up into shreds, or if small loose clouds are visible floating at a low level, underneath a large Nimbus, they may be described as Fracto-nimbus ("Scud" of sailors).

8. CUMULUS (Cu.). WOOL-PACK CLOUDS. *Thick clouds of which the upper surface is dome-shaped and exhibits protuberances while the base is horizontal.* These clouds appear to be formed by a diurnal ascensional movement which is almost always observable. When the cloud is opposite to the sun, the surfaces usually presented to the observer have a greater brilliance than the margins of the protuberances. When the light falls aslant, these clouds give deep shadows; when, on the contrary, these clouds are on the same side as the sun, they appear dark, with bright edges.

The true Cumulus has clear superior and inferior limits. It is often broken up by strong winds, and the detached portions undergo continual changes. *Fracto-cumulus.*

9. CUMULO-NIMBUS (Cu-N.). THE THUNDER-CLOUD; SHOWER-CLOUD. *Heavy masses of cloud, rising in the form of mountains, turrets, or anvils, generally having a sheet or screen of fibrous appearance above ("false Cirrus"), and underneath, a mass of cloud similar to Nimbus.* From the base there usually fall local showers of rain or of snow (occasionally hail or soft hail). Sometimes the upper edges have the compact form of Cumulus, forming into massive peaks round which the delicate "false Cirrus" floats, and sometimes the edges themselves separate into a fringe of filaments similar to that of the Cirrus cloud. This last form is particularly common in spring showers.

The front of thunder clouds of wide extent frequently presents the form of a large bow spread over a portion of the sky which is uniformly brighter in colour.

10. STRATUS (S.). *A horizontal sheet of lifted fog.* When this sheet is broken up into irregular shreds by the wind, or by the summits of mountains, it may be distinguished by the name of *Fracto-stratus.*

INSTRUCTIONS FOR OBSERVING CLOUDS.

For each observation the following points are to be noted and entered in the register or schedule.

1. *The kind of cloud* indicated by the initial letters of the name of the cloud (for greater precision, the number of the plate in the *Atlas* which most nearly resembles the form observed, might be given [Example C. 3].)

2. *The direction from which the clouds come.*

By remaining perfectly still for several seconds, the movement of the clouds may easily be observed in relation to a steeple or pole erected in an open space. If the movement of the cloud is very slow, the head should be steadied by using a rest. This method of observing must only be used for clouds near the zenith, for if they are distant from it the perspective may lead to errors. In such cases the nephoscope must be used, and in each case the rules given for the kind of instrument in use must be followed.

3. *The point of radiation of the upper clouds.*

These clouds often take the form of narrow parallel lines, which by reason of the perspective, appear to issue from a given point on the horizon. The "point of radiation" is the name given to the point where these belts or their prolongations meet the horizon. This point on the horizon should be indicated in the same manner as the direction of the wind, N, NNE, etc.

4. "*Undulated clouds.*"

It often happens that the clouds have the appearance of regular striæ, parallel and equidistant, like waves on the surface of the water. This is mostly the case with the Cirro-cumulus, Strato-cumulus (Roll-Cumulus), etc.

It is important to note the direction of these striæ. When two distinct

systems are apparent, as is often seen in clouds separated into globular masses by striæ in two directions, the directions of these two systems should be noted.

As far as possible these observations should be taken of striæ near the zenith, so as to avoid errors caused by perspective.

5. *The density and situation of a bank of Cirrus.*

The upper clouds often assume the form of a tangled web or sheet, more or less dense, which as it appears above the horizon looks like a thin bank of a light or greyish colour. As this form of cloud is closely connected with barometrical depressions, it is necessary to observe:—

(a.) The density.

0 = very thin and irregular.
1 = thin, but regular.
2 = fairly thick.
3 = thick.
4 = very thick and of a dark colour.

(b.) The direction in which the sheet or bank appears thickest.

6. *Remarks.*—All interesting particulars should be noted, such as:—

i. During summer all lower clouds as a rule assume special forms, resembling more or less Cumulus. In such cases an entry should be made in the column for "Remarks," *Stratus*, or *Nimbus cumuliformus.*

ii. It sometimes happens that a Cumulus presents a mammilated lower surface. This appearance should be noted under the name of *Mammato-cumulus.*

iii. It should always be noted whether the clouds seem to be stationary or in very rapid motion.

DISCUSSION.

Mr. F. Gaster exhibited and described a number of lantern slides of clouds which he considered represented the various forms described in the Report.

Capt. D. Wilson-Barker said he would like to ask Mr. Scott if the primary classification was supposed to bear any relation to the names of the clouds which followed after. Were the altitudes given for certain latitudes, or for all the world? He very much doubted if there were any clouds above the "Nimbus." His own impression was that the "Nimbus" cloud was one that grew downwards. He would also suggest that the sun, moon, and stars were useful aids in determining the motion of clouds. He could not see how the density could very well be denoted by number. After a slight glance through the Rev. Clement Ley's monograph on the subject, he was convinced that his classification was in every way superior to that recommended by the International Committee. He could only consider that this proposed nomenclature was a slight advance on that of Luke Howard. He was very much interested in the able way in which Mr. Gaster fitted in the photographs to the proposed names, and thanked Mr. Scott for bringing the matter before them.

Hon. Rollo Russell said that he had read the report with great interest, but was unable without further examination to offer any criticism on the classification adopted. The limiting altitudes given appeared to be stated rather precisely, and he should like to know whether they were intended to represent absolute limits, or whether they were the result of an average of a number of observations. The heights of alto-cumulus and cumulo-nimbus would seem to stand for average altitudes, as these clouds were frequently observed with tops

at a much higher level and with a lower base. Cirrus clouds were to be seen at greater heights than those usually given, and sometimes float, as balloon observations have proved, at higher altitudes than aeronauts have ever reached.

Mr. M. Jackson thought that it would be a useful arrangement if meteorologists who were in need of instruction in the methods of cloud observing, were to take excursions into the country under the guidance of a competent cloud authority, for the purpose of studying cloud formations. He had frequently noticed how greatly the clouds differed in various localities and countries. The prevailing clouds of Scotland were, in his opinion, quite distinct in form from those to be seen in the Isle of Thanet (where he had resided for the greater part of his life), and these latter were different from such as were common in the skies of Italy. Ruskin had stated that the finest sunset clouds visible in England were those to be seen in the Isle of Thanet; and he (Mr. Jackson) would like to know why the clouds common there should differ so greatly from those which were to be observed in Argyllshire, for instance. He had watched clouds over the Atlantic before the approach of a storm, and had seen them assume most remarkable forms. It would be interesting to have an explanation of the variation in the prevailing forms of clouds in different latitudes.

Mr. C. Harding said that from his experience in connection with the discussion of observations made at sea, he was sure that sailors would be grateful to the International Committee for the limited cloud nomenclature which had been adopted, the classification being only a just and wise extension of Luke Howard's. He was pleased that Mr. Gaster favoured it, as he (Mr. Harding) did not agree with the classification which Mr. Gaster had himself suggested a short time since. He could not agree with Capt. Wilson-Barker that Mr. Ley's nomenclature was superior to that embodied in the Report of the International Committee; and he was sure that the elaborate classification suggested by Mr. Ley would not do for ordinary use, as there was a great deal too much to master in it. The members of the International Cloud Committee were all men of good standing and thoroughly competent to accomplish the object for which the Committee was formed; consequently their proposals were likely to be readily accepted. He had compared the Committee's Report with the *Cloud Atlas* issued by Dr. K. Singer two or three years ago, and had been much surprised to see how closely the two agreed.

Mr. J. G. Wood thought that a series of successive pictures of cloud changes by means of photography would be most valuable, and a great aid to the successful study of cloud forms. There was no more difficult subject to photograph than a cloud, and he suggested that it was desirable that a set of simple rules should be drawn up for the guidance of any desiring to take up this interesting branch of scientific work.

Mr. Birt Acres said that his own observations of clouds had led him to conclude that there were really only two varieties—clouds which were formed near the earth, and those which were produced at high altitudes. As a result of the experience he had gained in cloud photography, he had found it necessary to adopt two systems, one being to employ a Nicol prism, and the other to use a black mirror, similar to that employed by Mr. Clayden. For cirrus clouds he had been obliged to use a plate very sensitive to the less refrangible rays, ordinary plates being practically insensitive to these rays, and often in addition to use a yellow screen as well as the polarising apparatus.

Mr. R. H. Scott said that the altitudes stated in the Report referred to Northern Europe, as the measurements upon which they were based were made at Upsala and Potsdam. Regarding Mr. Jackson's remarks concerning the differences in the cloud forms in different latitudes, the Hon. R. Abercromby some years ago read a paper before the Society in which he showed that cloud forms were identical all over the world. The difference between the clouds in the Highlands of Scotland and those in the Isle of Thanet was probably due to the great dissimilarity in the configuration of the ground in these two districts, Scotland being hilly, and Thanet flat, so that in the latter locality a better horizon was secured, and the conditions were more favourable for watching the progress of clouds. Mr. Scott also stated that the selection of typical pictures for the *Cloud Atlas* was carried out in as unbiassed a manner as possible, all names and marks of identification being removed from the photographs submitted for inspection by the Committee; and he stated his readiness to represent

to Dr. Hildebrandsson the wish of the Meeting that some explanation of the methods of measurement should be introduced into the preface to the forthcoming Cloud Atlas.

METEOROLOGICAL OBSERVATIONS AT MOJANGA, MADAGASCAR, DURING 1892-1894.

By STRATTON C. KNOTT, H.M. Vice-Consul.

(Communicated by R. H. Scott, F.R.S.)

[Received November 28th.—Read December 19th, 1894.]

MOJANGA is situated on the north-west of Madagascar, on the coast of Betsiboka Bay, in latitude 15° 43′ 0″ S, and longitude 46° 19′ 15″ E. Although the period over which these observations extend is but short, it has been thought the results obtained would be of interest in view of the scanty information we possess for the island.

The meteorological station is about 1 mile from the town, and stands on a plain 136 feet above the sea level. From south-east to south there is a view of Betsiboka Bay, and from south-west to north-west the open sea is visible.

The station itself is a piece of land about 100 yards long and 70 yards broad, given to me for the purpose by the Malagasy Governor. The exposure of the instruments is very good, there being no buildings to affect the readings, and but few trees near, and those but small. From the observatory plain the ground gradually slopes away. At 6 miles due north are the hills of Pajony, about 400 feet high.

The barometer is by Adie, and has an error of ·005 in.; its cistern is 140 feet above mean sea level. All the thermometers have been verified at Kew, and corrections have been applied for any errors. The rain gauge is by Casella; it is 8 inches in diameter, and its rim is 1 foot above the surface of the ground.

The observations were taken daily at 11 a.m. and 5 p.m. The dry and wet bulb thermometers by Messrs. Negretti & Zambra, and the maximum and minimum self-registering thermometers by Casella, are exposed in a screen under a shed which is open all round, is 4 feet from the ground, and has a ventilator. The values of the dew point, humidity, and vapour tension have been computed by Glaisher's *Hygrometrical Tables*.

All the instruments have been supplied by the Meteorological Council.

The solar radiation thermometer only arrived in September, and unfortunately the terrestrial minimum was damaged in transit, and had to be returned, but for the year 1894 the following instruments have been added


MADAGASCAR.
C. Amber
Diego Suarez B.
Vohimar Pt.
Passandava Bay
Bembatoka Bay
Mojanga
R. Sofia
Antongil Bay
ST MARIE I.
C. St Andrew
Fenoarivo
TAMATAVE
ANTANANARIVO
Andovoranto
Mahanoro
Mahela
Masindrano
FIANARANTSOA
Vohipeno
FARAFANGANA
R. Mangoky
St Augustine Bay
R. Onilahy
Fort Dauphin
C. St Mary
MOZAMBIQUE CHANNEL
INDIAN OCEAN
SAKALAVA
MERINA
BETSILEO
BETSIMISARAKA
IBARA
SIHANAKA
15°
20°
25°
45°
50°

to those already in use :—Cup and dial anemometer, by Casella; terrestrial minimum radiation thermometer, by Casella; two earth thermometers, for depths of 18 inches and 42 inches, by Troughton and Simms.

The observations began in April, 1892, and the accompanying tables are for the two years April, 1892, to March, 1894. The observations are still being continued.

Pressure.—The average pressure for the whole period was at 11 a.m. 30·039 ins., and at 5 p.m. 29·965 ins.; and the mean range between the two observing hours was therefore ·074 in. The highest mean pressure in any month (taking the mean of 11 a.m. and 5 p.m.) was 30·155 ins. in August, 1893; the lowest 29·842 ins. in January, 1893.

The highest absolute reading of the barometer was 30·265 ins. on July 19th, 1892, at 11 a.m., and the lowest reading was 29·689 ins. on January 23rd, 1893, at 5 p.m. Six days later, namely on the 29th, there was a strong gale from North-west, when the wind reached force 9, but the lowest pressure recorded during the gale was only 29·738 ins.

Temperature.—The mean temperature (mean of maximum and minimum) was 80°·2 in 1892-3, and 79°·1 in 1893-4, and for the two years 79°·7. The mean maxima ranged from 91°·4 in April, 1892, to 84°·5 in July, 1893, and the mean minima varied between 64°·9 in July, 1893, and 75°·1 in March, 1894. The absolute extremes were 98°·8 in November, 1892, and 60°·0 in January, 1893, a range of 38°·8.

In every month during the period except two (June and July 1893) the maximum temperature exceeded 90°, while in eight months the minimum did not fall below 70°.

The coldest month appears to have been July 1893, with 74°·7; while April 1892 was the hottest, with a temperature of 82°·9.

The depression of the wet-bulb was, as might be expected, large, the means ranging from 19°·1 at 11 a.m. in September 1892 to 5°·3 at 5 p.m. in January 1894, the means being in 1892-3 10°·6, and in 1893-4 10°·7. The highest individual difference reported was 24°·0 at 11 a.m. on October 23rd, 1892.

Hygrometry.—August and September are the driest months, with a vapour tension of from ·400 in. to ·500 in. and a relative humidity of as low as 34 per cent.

The mean difference in the vapour pressure at 11 a.m. compared with that at 5 p.m. is ·067 in., the value at 5 p.m. being higher by that amount; while the humidity is nearly 10 per cent. greater in the afternoon than in the middle of the day.

Solar Radiation.—Observations of the solar radiation were taken from September 1893 with a black bulb maximum *in vacuo*, and for the seven months till March 1894 the results show monthly means varying from 152°·4 in January to 157°·0 in February, with an absolute maximum of 177°·4 on February 7th.

A grass minimum was obtained and observations begun on January 10th, 1894. In the period of nearly three months the lowest temperature observed was 70°·0, on March 12th.

RESULTS OF OBSERVATIONS MADE AT MOJANGA. MADAGASCAR.
Long. 46° 19′ 15″ E. Lat. 15° 43′ 0″ S. Height above Mean Sea Level 134 feet.

1892–3.	Mean Pressure at Sea Level.		Air Temperature.								Humidity.				
					Means.		Extremes.				Depression of Wet Bulb.		Tension of Vapour.		Per cent.
	11 a.m.	5 p.m.	11 a.m.	5 p.m.	Min.	Max.	Min.	Date.	Max.	Date.	11 a.m.	5 p.m.	11 a.m.	5 p.m.	11 a.m.
	ins.	ins.	°	°	°	°	°		°		°	°	in.	in.	%
April	29·971	29·904	87·2	85·8	74·4	91·4	70·1	30	95·3	5 & 25	11·2	9·1	·705	·754	54
May	30·072	30·005	84·4	83·3	70·5	88·8	68·0	22, 24, 31	92·2	8	13·1	11·0	·570	·617	48
June	·088	·024	82·0	81·6	68·5	87·5	61·4	24	91·9	12	14·2	12·5	·486	·530	44
July	·145	·078	81·4	80·5	68·2	86·9	64·1	28	90·5	22	15·3	12·4	·445	·511	41
Aug.	·091	·016	83·0	78·8	68·2	88·3	65·1	2	92·9	11	14·4	8·2	·500	·617	44
Sept.	·114	30·037	86·3	80·7	68·4	91·3	65·1	2	94·8	9	19·1	10·0	·429	·595	34
Oct.	30·054	29·982	86·7	80·7	72·6	90·1	69·9	2	97·0	15	15·1	7·6	·555	·683	44
Nov.	29·994	·929	87·2	82·3	74·1	90·6	70·2	2–9	98·8	16	13·8	7·9	·609	·712	46
Dec.	30·009	·933	84·2	82·8	73·4	87·9	70·2	11–25	94·1	31	8·5	7·4	·737	·745	63
Jan.	29·875	·809	83·5	81·6	73·0	86·0	60·0	28	92·8	15	7·4	6·0	·762	·775	66
Feb.	·966	·893	84·3	83·8	74·8	87·0	67·9	12	90·9	24	7·5	6·9	·781	·794	66
Mar.	29·952	29·880	84·3	84·8	73·6	88·1	70·5	6	92·7	24	8·4	8·2	·743	·767	63
Year	30·028	29·958	84·5	82·2	71·6	88·7	..	..	..	..	12·3	8·9	·610	·675	51·1

1892–3.	Amount of Cloud.		Rainfall.			Weather. No. of Days of					Wind. No. of Observations of							
				Greatest Fall.														
	11 p.m.	5 p.m.	Total.	Amount.	Date.	Rain.	Thunderstorms.	Clear Sky.	Overcast.	Gale.	N.	NE.	E.	SE.	S.	SW.	W.	NW.
			ins.	ins.														
April	2·4	2·8	2·45	1·41	9	4	3	16	3	1	6	3	8	9	4	10	3	17
May	0·2	0·5	..	..	..	0	2	28	0	0	1	0	1	13	13	20	2	11
June	0·9	1·3	..	..	..	0	0	22	0	0	0	0	10	21	11	13	0	3
July	0·8	2·4	0·01	0·1	28	1	0	23	1	0	3	3	15	8	13	10	0	7
August ..	1·3	1·6	..	..	..	0	0	23	0	0	8	5	8	6	4	8	2	21
September	0·8	3·3	0·07	·07	28	1	1	17	0	0	5	16	9	6	1	3	6	14
October ..	2·2	2·6	2·71	1·64	30	5	5	17	4	0	13	9	3	2	1	4	16	13
November	2·5	3·5	3·40	2·21	20	6	9	16	0	0	15	3	4	3	2	1	18	13
December	6·6	6·3	7·14	2·22	22	12	21	2	8	0	28	5	1	0	1	0	2	18
January	7·4	7·7	20·64	4·13	29	18	17	2	17	1	24	3	3	0	2	3	5	23
February	6·3	5·6	6·17	1·69	16	11	16	3	7	0	10	7	3	1	1	2	7	22
March ..	6·0	5·9	14·67	2·75	5	13	20	2	5	0	23	5	4	9	1	6	3	9
Year....	3·1	3·6	57·26	..	..	71	94	171	45	2	136	59	69	78	54	80	62	171

Rainfall.—The rainy season extends from October to April, with a very striking decrease in amount fo February. The average total fall for the year is 54·59 ins., the monthly falls ranging from *nil* to 20·64 ins. in January 1893. May to September are dry months, and the three months June to August are practically rainless. Some heavy daily falls of rain are reported, the maximum being 5·43 ins. in January 1894, with two others of upwards of 4 inches.

During the two years there were 36 days in which the rainfall exceeded

RESULTS OF OBSERVATIONS MADE AT MOJANGA, MADAGASCAR.
Long. 46° 19′ 15″ E., Lat. 15° 43′ 0″ S. Height above Mean Sea Level 134 feet.

1893-4.	Mean Pressure at Sea Level. 11 a.m.	Mean Pressure at Sea Level. 5 p.m.	Air Temperature. 11 a.m.	Air Temperature. 5 p.m.	Air Temperature. Means. Min.	Air Temperature. Means. Max.	Air Temperature. Extremes. Min.	Air Temperature. Extremes. Date.	Air Temperature. Extremes. Max.	Air Temperature. Extremes. Date.	Humidity. Depression of Wet Bulb. 11 a.m.	Humidity. Depression of Wet Bulb. 5 p.m.	Humidity. Tension of Vapour. 11 a.m.	Humidity. Tension of Vapour. 5 p.m.	Humidity. Percentage. 11 a.m.	Humidity. Percentage. 1 p.m.
	ins.	ins.	°	°	°	°	°		°		°	°	in.	in.	%	%
April ..	30·012	29·933	84·9	84·6	73·1	87·8	69·8	8	92·1	1	9·9	8·9	·698	·732	58	62
May ..	·073	30·025	83·7	82·3	70·7	87·4	65·2	26	91·7	2	11·9	9·1	·595	·665	51	60
June ..	·125	·049	80·3	79·6	66·4	84·7	61·1	26	87·9	28	14·0	11·1	·460	·534	44	53
July ..	·152	·078	79·8	79·8	64·9	84·5	62·0	11	88·6	29	14·4	12·7	·442	·488	43	48
August	·197	·112	82·9	81·6	66·0	87·4	63·3	28 & 29	90·7	19	17·6	13·9	·412	·489	37	45
Sept ..	·094	30·020	85·4	78·6	68·1	88·2	63·0	5	93·5	27	17·5	7·8	·458	·627	37	64
October	·048	29·969	86·0	80·7	71·8	88·4	66·2	6	94·4	20	14·5	7·6	·557	·683	45	65
Nov. ..	30·061	·973	86·6	81·9	72·8	89·1	69·1	8	93·9	17 & 18	14·9	8·4	·558	·683	44	62
Dec. ..	29·998	·912	84·2	82·4	74 2	86·7	70·2	14	92·2	16	8·9	7·0	·720	·752	61	68
January	·924	·853	82·7	82·0	73·7	85·6	71·0	10 & 16	91·3	8	6·5	5·8	·781	·794	70	73
Feb.	·934	·854	84·8	84·7	74·6	87·9	71·2	15	93·2	5	8·0	7·4	·775	·799	65	66
March..	29·965	29·887	85·3	85·6	75·1	88·6	72·3	26	95·5	4	9·0	8·5	·746	·775	61	62
Year ..	30·049	29·972	83·9	82·0	71·0	87·2	..	..	..	..	12·3	9·0	·600	·668	51·3	6·07

1893-4.	Amount of Cloud. 11 a.m.	Amount of Cloud. 5 p.m.	Rainfall. Total.	Rainfall. Max.	Rainfall. Date.	Weather. No. of Days of Rain.	Thunderstorms.	Clear Sky.	Overcast.	Gale.	Wind. No. Observations of N.	NE.	E.	SE.	S.	SW.	W.	NW.	Calm.
			ins.	ins.															
April	4·3	4·1	4·11	1·75	7	5	14	9	5	0	14	3	6	12	2	6	2	11	4
May ...	2·7	3·4	0·68	·49	12	3	4	17	5	0	2	1	6	16	11	9	1	15	1
June	1·0	2·3	..	..	..	0	0	19	0	0	0	2	7	21	7	10	2	10	1
July	1·5	3·7	..	..	..	0	0	17	3	0	1	3	10	26	8	5	5	3	1
August ..	1·3	5·0	..	..	..	0	0	8	0	0	1	9	17	16	3	2	0	11	3
September	1·2	2·2	0·32	·31	26	2	0	20	2	0	7	4	7	14	1	1	3	23	0
October ..	2·4	2·0	3·80	3·28	23	3	5	17	1	0	3	0	2	14	4	0	5	34	0
November	3·7	2·2	1·09	·60	28	5	3	13	2	0	2	3	0	11	4	1	5	34	0
December	6·0	5·9	11·68	4·64	5	11	12	3	10	0	10	1	3	2	1	1	4	39	1
January ..	8·8	9·3	18·62	5·43	15	17	18	0	27	0	3	3	3	4	3	5	4	37	0
February	8·1	6·8	3·64	1·09	20	13	14	0	15	0	7	6	4	3	1	3	5	22	5
March ..	6·5	4·6	7·97	2·62	25	16	18	4	8	0	9	7	1	10	1	6	1	23	4
Year	4·0	4·3	51·91	..	..	75	88	127	78	0	59	42	66	149	46	49	37	262	20

one inch, on 17 of which the fall was 2 ins. and upwards: the number of rainy days was, however, in no case excessive. Even in the wettest months the days of rain did not exceed 18, while for the rainy season (October to April) the average in each of the two years was 10 per month.

Cloud.—The cloudiness followed the rainfall, being greatest in January, the month of the greatest rainfall, and low from May to September, the dry months. On the average of all months, 5 p.m. was slightly more cloudy than 11 a.m., and this was invariably the case in the dry season. The days

of clear sky were numerous from April to November, but in December, January, and February, the sky was frequently overcast.

No hail was observed in the period under review, and there were but two cases of gale. Thunderstorms were common in the rainy season, the average number of days of thunderstorm from December to April being as high as 15. The highest number in any month was 21 in December, 1892. In two months, December 1892 and March 1894, sheet lightning was seen on as many as 27 days.

Wind.—The wind summaries show that the prevalent direction during the rainy season was North-westerly, while in the dry season (May to September) the wind was commonly between South and East. In 41 instances during the two years the wind was reported calm.

ANTANANARIVO.

Observations have been regularly taken for several years past at the London Missionary Society's College at Antananarivo, and it may be interesting to note the difference between the results for the capital and those for Mojanga. The College is situated 4,700 feet above sea level.

The observations for 1894 are not yet available, but for the 21 months, April, 1882, to December, 1893, the comparative results are as follow :—

	Temperature.			
	Means.		Absolute.	
	Minimum.	Maximum.	Minimum.	Maximum.
	°	°	°	°
Mojanga	70·8	88·0	60·0	98·8
Antananarivo	52·9	68·1	40·0	86·5

The rainfall-measuring glass was stolen in August, 1892, and was not replaced till January, 1893. The rainfall values therefore are only available for the purposes of comparison for the period April to July, 1892, and January to December, 1893. For this 16 months the results are :—

	Rainfall for 16 months.			
	Total.	Maximum.	No. of Rainy Days.	Days with 1 inch and upwards.
	in.	in.		
Mojanga	65·62	4·64	76	23
Antananarivo	59·13	4·70	108	21

These notes have been entirely drawn up by Mr. J. A. Curtis, of the Meteorological Office.

It will no doubt be interesting to append a summary of the observations taken at the College, extracted from *The Antananarivo Annual.* For the years prior to 1887 the annual quantities of rain are all that are given; with that year the publication of monthly totals of rain, as well as of extreme temperatures, was commenced.

Maximum and Minimum Temperatures at Antananarivo, Madagascar.

Month.	1887.		1888.		1889.		1890.		1891.		1892.		1893.		Mean.	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
January	70·9	68·1	77·0	60·4	75·7	60·6	77·0	59·5	74·4	57·2	76·4	58·7	74·4	56·7	75·1	60·2
February	73·9	65·1	77·9	61·1	77·3	61·8	76·5	60·2	76·0	59·3	74·1	59·8	72·9	57·3	75·5	60·7
March ..	75·5	64·3	72·6	57·9	73·7	59·8	73·9	59·0	70·7	57·2	72·2	57·3	71·5	56·0	72·9	58·8
April	69·9	57·4	68·8	55·6	70·1	57·5	70·2	57·3	67·8	55·8	69·5	56·0	67·3	54·3	69·1	56·3
May	66·5	53·7	68·8	53·8	67·0	53·0	63·0	50·9	63·3	50·2	62·8	49·8	63·0	51·8	64·9	51·9
June	60·8	46·1	63·8	50·5	61·5	48·1	58·9	45·6	61·2	47·7	58·5	46·9	60·6	50·9	60·8	48·0
July	61·6	48·0	61·7	48·6	61·7	47·8	59·7	47·1	58·7	45·5	58·8	45·4	57·4	44·4	59·9	46·7
August ..	61·9	46·6	62·5	48·9	61·4	47·9	62·0	47·1	60·3	45·3	63·6	47·6	62·4	48·9	62·0	47·5
September	67·1	50·3	68·6	51·2	67·1	50·2	64·6	48·1	66·0	49·7	63·4	46·1	69·4	58·6	66·6	50·6
October ..	71·8	55·1	73·5	56·2	70·3	53·2	70·4	52·2	71·5	53·7	72·3	51·5	75·4	61·8	72·2	54·8
November	77·1	57·1	75·7	58·2	76·6	57·4	73·5	56·0	74·3	54·8	74·8	54·0	76·7	55·3	75·5	56·1
December	75·3	57·6	77·7	60·8	77·9	59·3	73·6	57·0	77·9	58·3	76·0	56·9	79·4	60·4	76·8	58·6

Yearly Rainfall.

1881.	1882.	1883.	1884.	1885.	1886.
42·12	41·08	57·65	68·86	52·19	47·28

Monthly Rainfall at Antananarivo.

Month.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	Means 1887–1893.
	in.	in.	in.	in.	in.	in.	in.	in.
January	17·56	9·56	11·26	7·04	3·35	16·31	11·67	10·96
February	14·28	6·73	11·98	7·55	8·11	10·89	11·30	10·12
March	9·87	9·62	6·32	4·14	11·10	1·09	5·87	6·86
April	·43	3·07	1·87	6·15	·94	1·79	3·41	2·52
May	2·12	·02	...	·04	·08	·10	2·38	·68
June	...	·15	1·11	·51	·06	·19	·42	·35
July	·43	·05	·13	·12	·12	·03	·35	·18
August	·52	·19	·27	·10	·06	·46	·03	·23
September	2·43	1·64	·46	·07	·15	·17	·03	·71
October	2·34	2·17	·39	4·90	10·84	2·21	1·97	3·55
November	7·05	10·57	4·25	7·43	·83	2·96	·60	4·81
December	7·95	7·28	11·71	14·67	6·75	11·07	18·98	11·20
Year	64·98	51·05	49·75	52·72	42·39	47·27	57·01	52·17

FLOODS IN THE WEST MIDLANDS.

By HENRY SOUTHALL, F.R.Met.Soc.

[Received December 13th.—Read December 19th, 1894.]

The great interest now taken in the subject of river floods, no doubt increased of late by published accounts of circumstances attending the recent remarkable overflow of the Thames and other rivers in November last, may furnish some reason for placing on record the result of observations extending over a considerable number of years.

Since the subject of "Floods on the Thames" is likely to be dealt with at an early date by Messrs. Symons and Chatterton, the present paper will refer almost exclusively to those of the rivers Severn, Wye, and Usk, with some additional reference to the floods at Bath, caused by the Wiltshire Avon.

The term "West Midlands" may be considered to mean Herefordshire and the adjoining English and Welsh counties.

One other preliminary remark. When I offered at the last Council Meeting to give some information, partly from my own observation and partly what I may have gained from other sources, it did not at the time occur to me that the interesting paper[1] read by Messrs. Marriott and Gaster on the Floods of May 1886 had already given many particulars and facts relating to our Western inundations, which I had the pleasure of furnishing. I shall therefore endeavour to avoid needless repetition.

The accompanying map gives some idea of the geographical features and boundaries of the districts referred to, and has been copied from the *Ordnance Survey Map of the Rivers in England and Wales.*

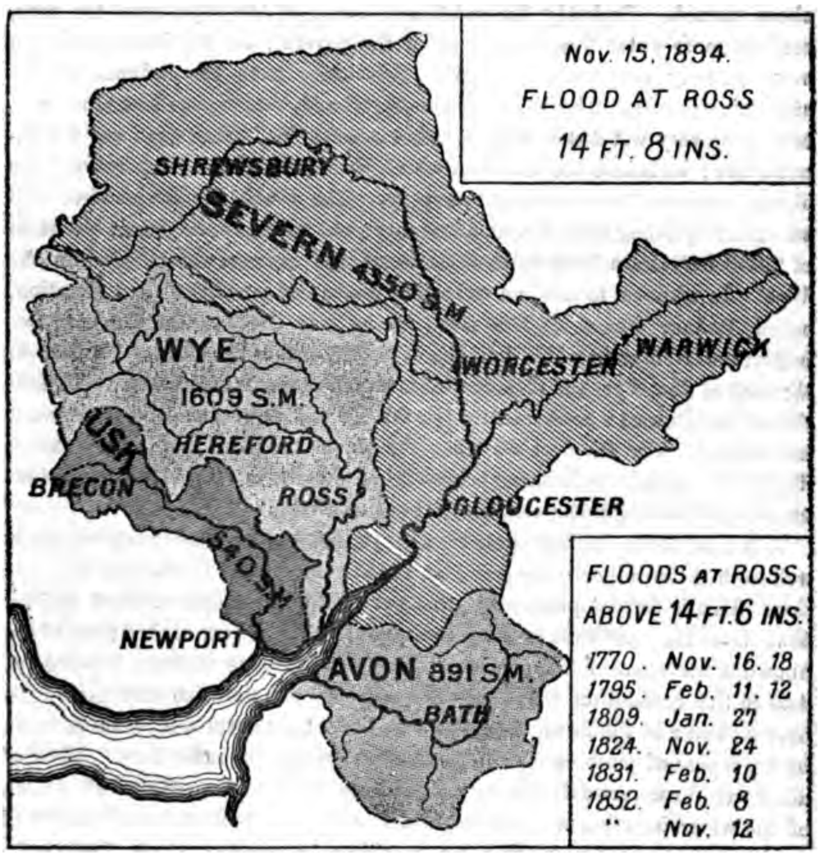
The following table gives the area in square miles of the several basins, the length of their main streams, and also that of their principal tributaries. For comparison, similar details are furnished for the Thames, Trent, and the Yorkshire and Bedfordshire Ouses, which are the only other rivers in England as large as the Wye.

It must be borne in mind that the different rivers vary very much in their characteristics, and that the amount of water discharged in proportion to the distance traversed, or the area drained, is much greater in some than others, especially in time of flood. This, no doubt, depends mainly upon the quantity of rain falling in each district; but the conformation of the ground, and the receptivity of the soil, are also important factors. Even if we can ascertain, with a good degree of precision, the amount of deposit in the shape of rain or snow upon a certain area per square mile, it is surely exceedingly difficult to say how much of this finds its way into the rivers. The previous state of the ground, as regards saturation, will affect the

[1] *Quarterly Journal*, Vol. XII. p. 269.

COMPARATIVE TABLE SHOWING AREA DRAINED BY THE RIVERS NAMED, WITH THEIR LENGTHS IN MILES.

River.	Catchment Basin, Area Sq. Miles.	Length Main Stream, in Miles.	Total Tributaries, in Miles.	Principal Tributaries, with lengths of each.
Thames	4,613	111	541	Lea, 50; Kennet, 45; Cherwell, 40
Severn	4,350	158	446	Avon, 85; Teme, 64
Trent	4,052	147	386	Derwent, 54; Meden, 42
Ouse (Bedfordshire)	2,607	143	178	Branden, 38; Cam, 30
„ (Yorkshire)	1,842	65	258	Swale, 64; Ure, 54; Nidd, 47
Wye (Herefordshire)	1,609	135	182	Lug, 40; Ithon, 29; Arrow, 26; Irven, 21
Avon (Wiltshire)	891	62	29	
Usk	540	65	..	None of any consequence
Total	20,504	886	2,020	



River Basins of the West Midlands.

amount of percolation into it; evaporation at the same time varying with different conditions of wind, dryness of the air, and temperature. Of course it is easy to compute, approximately, the volume of water carried down by a

river in flood, at any particular point or bridge, where the width of the river, the depth of the stream, and the speed of the current is known; but it is not so easy to ascertain how much of the total rainfall will at any time descend along the watercourse. A comparison of the different drainage areas tabled will show that the Severn stands midway in extent between the Thames and Trent, and that the Yorkshire Ouse is slightly greater than the Wye; while there is not much difference in the length in miles of the main streams of the Severn, Wye, and Trent—that is, excluding tidal portions of each.

The rivers Severn and Wye, rising within a very short distance of each other in the Welsh Mountains, near the summit of Plinlimmon, where the rainfall is probably double that of the districts where the Thames, Trent, or Ouse have their sources, are consequently subject to higher, if not more frequent, floods; and in proportion to their drainage area a relatively greater amount of water flows down them than is the case of the more eastern rivers above named. Probably the catchment basin of the Wye, acre for acre, receives more water than even that of the Severn; for the latter, taking a more easterly course than the Wye, gets away from the influence of the mountains sooner. The Wye, on the other hand, flowing southward at first, taps some very wet districts in its upper reaches in Radnorshire and Brecknockshire; including the one from which the Birmingham Corporation have elected to obtain their new water supply. The Black Mountains also, with an extent equalling that of a small county, and having a maximum elevation of 2,660 feet, drain both on their northern and eastern watersheds into the Wye. In addition to this, an extensive plateau of somewhat less elevation, called Radnor Forest (2,166 feet), drains into the Lug and Arrow, two important tributaries which join the Wye just below Hereford. Further in the case of the Wye, the distance from source to sea is only about two-thirds that of the Severn; consequently the fall per mile is greater, and the current more rapid. For the first 50 miles the bed of the Wye is also very rocky. These may appear to be mere geographical details, but they to some extent explain differences in the conduct of the two rivers.

And now, before dealing specially with the flood of November last it may be well to state the authority for doing so, and also the mode of obtaining information. This is derived principally from personal observations made at various times from the year 1836 to the present date 1894. I have visited most of the known sites where flood marks or gauges exist, some of them repeatedly. And in this connection, may I be allowed to express the wish that more care may be taken in the future than has sometimes been exercised in the past, as to the choice of place on which to fix such gauges or indicators. First of all, I would recommend that they should not be just where the greatest rush of the water is, otherwise it will be difficult to ascertain the exact height of the level reached; the splash often reaching quite a foot above that mark. And, secondly, that it is important that the record should be as permanent as possible. In many cases flood marks are made by notches on door-posts, trunks of trees, &c.; and in other cases roughly painted or chalked on a

wall, with the result that they quickly become illegible. The brass plates let into the Cathedral steps at Worcester are models in this respect, those recording the height of the great floods in 1672 and 1770 being as clearly distinct as the day they were placed there.

It is also important, if possible, to have records of successive floods in closely adjoining places for sake of comparison—thus, for instance, at Worcester the mark of the great flood of 1795 is out of sight of, and a long way from the others just mentioned. At Hereford some are above and some below Wye Bridge, and quite out of sight of each other. In very high floods, by observing both, a comparison may be made, but at other times it is not possible to do so except by levelling. Very few flood marks are to be found in the higher parts of rivers, presumably because the flood does not rise so high, and soon runs off.

At Gloucester some interesting ones have within a few years been destroyed and removed. People seem very slow to learn the real practical utility of preserving them, and in this respect we are far behind some continental countries.

At Ross a rope maker, whose "rope walk" was likely to be flooded, marked accurately the height attained by the extraordinary flood of 1795, and also of many subsequent ones. He gave me before his death, at the age of 98, many of his recollections and experiences. Another intelligent boatman, who lived to a good age at Monmouth, could point to a stone in the bridge reached by the flood of 1809, the highest in *his* recollection. But such instances of thoughtful and accurate register are not frequent. On the lower side of Wilton Bridge, near Ross, there are several old flood marks, but many are now illegible. Those, however, with RH 78, RH 1795, cut into the stone are still decipherable. At Coalbrookdale there are quite a number of flood records on the gates of the old warehouse by the Severn side, which seem to be fairly accurate.

On the river Teme, we are greatly indebted to the late Mr. Davis, of Orleton, for his observations of rainfall since 1831, with the amounts registered, on the few days previous to most of the principal floods for a considerable length of time, and also for the information collected by him as to those of 1770, 1795, 1809, 1821, &c.

I have also carefully searched the files of old county newspapers, specially those printed in the county towns of Shrewsbury, Hereford, Worcester, and Gloucester. It is not always that the accounts given in these papers contain sufficiently definite information to be of any value ; such expressions as "greatest in living memory," "highest ever known," being sometimes used only a few years after a much greater flood. As a matter of fact, few persons' memories are to be trusted either as to height, or exact dates, the latter often being at least one year wrong. But where it is stated that the flood reached to within so many inches of another, some evidence is afforded of careful noting and accuracy. Many interesting particulars, however, are in my possession of incidents occurring in these floods, such as the destruction of bridges (a great many having been carried away in 1795,) the

stoppage of high roads and consequent delay of traffic, and also exciting accounts of drownings, loss of cattle, &c. The following from the *Hereford Journal* of 1770 is amusing. In reference to the overturning of the London stage waggon near Ross (coaches did not commence running till 1774), the quaint chronicler of that date says: "It is pleasant to reflect that the passengers were all got out before the accident happened."

Floods at Ross.

In reference to floods at Ross, I have found it convenient to sort them roughly into three classes:—

Primary or highest, all that are 14 ft. 6 ins. and more above summer level.
Secondary, those with a height of 12 ft. to 14 ft. 6 ins. " " "
Tertiary " " 10 ft. to 12 ft. " " "

Of these, none of the first have happened since November 12th, 1852, the previous instances of primary floods having been the following:—

1770—November 16th to 18th.	1831—February 10th.
1795—February 11th to 12th.	1852—February 8th.
1809—January 27th.	1852—November 12th
1824—November 24th.	

Very high floods, however, occurred on the Lug and Teme on the following dates:—

1815—Date not given.	1836—November 30th.
1821—September 9th.	1839—July 31st.

The two last were of the highest class, but I find no record of them on the Wye. That of 1839 was very high on the Severn.

In reference to these highest floods, it may be noticed that they all occurred in November or February, except that of 1809, which was at the close of January. It would also appear that very high floods are not nearly so frequent as in former years, particularly on the Wye. The reason for this may be, that with better drainage the flood in the lower reaches of the river is carried off before the upper flood arrives, and more quickly than formerly. Railway embankments and additional bridges are supposed by some to "keep back" the water. At any rate, we can scarcely attribute the decrease to diminished rainfall.

These floods seem to be due to at least three different causes. Firstly, to an atmospheric condition which seldom exists except in the period November to March inclusive. A strong South-westerly to Westerly gale—an extra violent one is said by the boatmen to "over blow" the hills, and an Easterly or Southerly one does not produce much effect on the river—a great rise of temperature, rapidly melting accumulated snow, whilst at the same time heavily-charged clouds, fresh from the Atlantic, driven against the cold mountain slopes, precipitate their moisture in the shape of very heavy rain. In the case also of the break up of a long severe frost, the masses of ice brought down with the flood, and choking or blocking up the arches of these bridges. When these conditions are combined, as in 1795, there occurs a

maximum flood. In 1814, when the memorable frost temporarily gave way in the beginning of February, the flood did not rise so high as in 1795 by about 3 feet, because the rise of temperature was not great enough to produce the same effect. Somewhat similar cases to 1795 occurred in February 1831 and February 1852, as well as in January 1809; whereas 1814 may be paralleled in 1838, 1855, 1878, 1879, 1881, and 1891, in each of which cases the Wye was firmly frozen all across, which is a very exceptional circumstance in so rapid a river.

Another condition also illustrated by the examples given of primary floods is one which often occurs in November, and that is the continuance of rains both in the mountain and lowland districts, till the soil becomes completely saturated. After this, three or four days' heavy rain will produce a great flood. Those in November 1770, 1824, 1836, 1852, and 1875 are typical instances, all of these having occurred about the middle of the month.

The third and last condition is that of heavy thunderstorms or cloudbursts, or the occurrence of very heavy partial or local rains. These are the cause of most of our summer floods. In May 1886 and July 1875, heavy downpours, without much apparent electric disturbance, produced locally extraordinary risings of the neighbouring streams. Of this character, too, was the great flood in Yorkshire, October 16th, 1892.

In the case of the waterspout or cloudburst in Breconshire, July 9th, 1853, the Usk rose to an unprecedented height, far beyond that of any previous time, houses being carried away and much damage being done, owing to the water coming down so suddenly and unexpectedly. An inscribed stone shows the height attained.

On May 27th, 1811, a storm broke over the country to the eastward of Hereford, lasting from 3 to 8 p.m., accompanied by torrents of rain. The Severn, at Worcester, is said to "have risen 6 feet in one hour, and 20 feet in twenty-four hours." On July 5th and 7th, 1852, violent thunderstorms occurred in the same district, which were said to have "carried everything before them."

On August 13th, 1858, 2·75 ins. of rain fell in 50 minutes; 3·84 ins. in 24 hours. The streets in Ross were flooded to a depth of 3 feet. On June 4th, 1891, four miles from Ross stone walls were swept down, and soil and crops removed from fields, from the enormous downpour over a very limited area.

Of summer floods affecting the larger rivers, the most notable examples are those of August 1799 and 1839, and July 1872. In each case large quantities of hay were washed down stream; 1839 being the most remarkable instance.

Floods of November 1894.

And now as to the recent flood of November 1894. The deficiency of rainfall, which commenced in Herefordshire in 1887, continued with a few breaks till October 22nd, 1894. The accumulated defect, taking the previous twenty years 1867-1886 as a standard of comparison, being as much as 42·85 ins., or equal to the average fall in 16 months. On October 23rd,

however, the rain which occasioned the flood set in, and by the 31st, that is in nine days, 6·78 ins. fell at Rhayader (Nantgwylt), near the source of the Wye, and 4·43 ins. at Ross, which is nearly a maximum record in the time for the latter place. On October 28th the river had only risen 7 feet. On November 2nd a height of 10 feet was shown by the gauge. There was then a fall, and it was not till after the renewed rain of November 11th to 14th, producing about 2 ins. of water more, that the Wye rose to 12 feet. From this time the river continued to rise till, at 8 p.m. on the 15th, a height of 14 feet to 14 feet 3 inches was reached, a limit which had scarcely been exceeded since November 1852, although several instances of floods of similar height had occurred in the interim. During the next 12 hours the water fell 22 inches, and then pretty quickly subsided, so that the river was contained again within its usual high banks. The lower or old road from Hereford (a new one was made after the coach had been left there in the flood in 1831) was impassable, and the whole valley, as seen from the Ross Prospect, was one wide lake. But little damage appears to have been done, nor much inconvenience caused, comparatively speaking.

I append tables showing the rainfall in different places, and also comparative heights of different floods as far as can be ascertained (pp. 86-88). More exact levellings are still needed to fix a good datum line, and it is hoped that before long there may be a more permanent set of flood-marks fixed in a conspicuous and suitable place, so as to make future comparisons more easy and simple. Further observations are also needed, so as satisfactorily to settle the difference of time between the top of the flood at different places on the river, speed of current, &c. It will be seen by these figures that the recent flood, though high, was not exceptionally so on the Wye, nor does it appear to have been so on the Severn, whilst on the Thames and Avon it was probably the highest of the century.

The following from *Keene's Bath Journal*, dated November 17th, 1894, gives a graphic account of the flood there :—

"All previous records in the way of floods have been beaten this week by the double disaster of Tuesday and Thursday. The flood of 1882 has hitherto been acknowledged to be the most disastrous of the century, though the water in 1809 is believed to have reached a few inches higher. This week, however, will be memorable in local history for having produced two floods, the latest quite eclipsing that of which any known record exists. The water reached its highest point at 3·30 a.m. Thursday, November 15th, and it then measured about a foot higher than 1882." It further on adds: "The flood level of 1882 is shown by a stone let into the wall, though the mark upon it was *not visible* owing to the growth of weeds." This in only 12 years! The account continues: "Several previous visitations stand out in the records of the century. The flood of 1809 was only a few inches above the level of 1882. It was caused by a heavy fall of snow followed by rain and consequent sudden thaw." Two horses attached to a coach were drowned at Batheaston in this flood. Then came the flood of 1821, then that of 1823 (? 1824), and afterwards 1828. This was the effect of a violent thunderstorm in July. "In this case a reservoir burst its banks. In 1841 two bridges were swept away. In 1866 the river rose 14 feet. In 1875 there were two floods, one in January, and one in November, 15 feet being the height of the latter. A similar one in January 1877. In 1878 a waterspout burst over Weston; that of October 24th, 1882, being the next except one in 1881."

To return to the Wye, Mr. S. C. Lewis writes me from Elan Valley, Rhayader, "The heaviest flood of this year (1894) took place on the night of July 24th. Rain set in at 2 p.m., and next morning No. 2 gauge showed a fall of 3·57 ins.," the rainfall at Ross for same time being 0·59 in. This is similar to my experience at Dolgelly on October 6th, 1874, on which occasion 3·75 ins. fell between 9 a.m. and midnight, against 0·55 at Ross.

Historic Floods.

I may perhaps be allowed to conclude this imperfect account of floods in our own times by some short reference to historic floods. I have not included any of the "secondary" ones since 1852, except that of 1894, and the "tertiary" are too numerous to mention, although in some of these last a large body of water comes down, flooding the meadows to a depth of nearly 2 feet. I append a list of approximate heights and dates of the "secondary" since 1852 (p. 38).

The first flood on the Severn of which we have any account occurred 14 A.D., followed by one in 115 A.D. and 352 A.D., or three during the Roman period—much people and cattle said to have been destroyed.

During the Saxon period there are again three records—487, 813, 1046.

In 813 the chronicle says "2,000 people and 7,000 cattle lost." Many of the records in the next 400 years speak of inundations, but in many cases it is not stated whether they were produced by sea or river. But in 1483 Hollinshead says:—

"In October the River Severn overflowed for 10 days, and carried away men, women, and children in their beds, and the flood was called 'the great waters' for a hundred years after."

In like manner we now look back on the great flood of 1795, just a hundred years since.

Hume gives more particulars:—

"But at that time there happened to fall such incessant rains, so heavy and continued, as exceeded anything known in the memory of man, and the Severn and other rivers in the neighbourhood swelled to a height which rendered them impassable."

This flood put an end to the Duke of Buckingham's insurrection.

In 1607 "a strong West wind caused such a flood in the Severn that in several towns and villages the waters rose higher than the house tops."

So that great floods are nothing strange. If the calculation be a correct one that in 48 hours during November 1894 a cubic mile of water fell over England south of the Humber, we may be thankful not to have suffered more than we have done.

Rainfall in Wye Valley and Borders, October 23rd to November 14th, 1894.

Station.	Pontshill, 3 miles S. of Ross.	The Graig, Ross.	Burghill, Hereford.	Farm, Leominster.	Lynhales, near Kingston.	Orleton, Tenbury.	Penybont, Radnor.	Nantgwyllt, Rhayader.	Clifton, Bristol.
Observer.	W. E. Hancock.	H. Southall.	Dr. Chapman.	Miss Southall.	S. Robinson.	T. H. Davis.	J. Hamar.	V. C. Lewis.	R. F. Sturge.
	in.	in.	in.	in.	in.	in.	in.	in.	in.
October 23	·44	·46	·42	Daily particulars not to hand.	Ditto.	·41	·66	1·22	
24	·80	·80	·41			·36	·60	·65	
25	·20	·22	·10			·30	·14	·27	
26	·94	·83	·76			·83	1·28	1·02	
27	·37	·31	·06			·77	·34	·56	
28	·40	·50	·20			·19	·60	1·03	
29	·25	·13	·03			·08	·25	·33	
30	1·15	1·08	·74			·52	·50	·75	
31	·14	·10	·05			·05	·17	·95	
November 1	·15	·12	·20			·21	·37	1·27	
2	·05	·07	·06			·05	·18	·18	
3	·25	·07	·22			·20	·28	·35	
4	·28	·01	·09			·02	·10	·18	
5	·02	..	·02			·01	..	·01	
6	..	..	·07			·01	·04	·10	
7	·42	·36	·46			·33	·40	·60	
8	·22	·24	·22			·17	·26	·21	
9	·02	·02	·02			·04	·02	·07	
10	·23	·12	·08			·10	·38	·82	
11	·20	·19	·13			·06	·15	·22	
12	·78	·62	·82			·92	·74	1·10	
13	·99	·83	·87			·82	1·07	1·89	
14	·40	·31	·24			·21	·05	·09	
Total October 23 to November 24	8·70	7·39	6·27	7·09	8·06	6 66	8·58	13·87	8·50
Total October 23 to 31	4·69	4·43	2·77	3·39	4·00	3·51	4·54	6·78	3·30
„ November 1 to 10	1·64	1·01	1·44	1·50	4·06	1·14	2·03	3·79	5·20
„ „ 11 „ 14	2·37	1·95	2·06	2·20		2·01	2·01	3·30	

Rainfall at Bath.

Previous to the two great floods, October 24th, 1882, and November 15th, 1894.

1882.	ins.
Total 30 days previous to Oct. 18 ...	3·59
Oct. 18 ...	·15
19 ...	·12
20 ...	·10
21 ...	·42
22 ...	·62
23 ...	1·12
24 ...	·32
Oct. 18 to 24. Total 7 days ...	2·85
Sept. 18 to Oct. 24. Total 37 days	6·44

1894	ins.
Total 30 days previous to Nov. 8 ...	4·18
Nov. 8 ...	·19
9 ...	·08
10 ...	·23
11 ...	·81
12 ...	1·14
13 ...	·79
14 ...	·61
Nov. 8 to 14. Total 7 days	3·85
Oct. 9 to Nov. 14. Total 37 days	8·03

Rainfall at Orleton, Worcestershire.

Records of late Mr. T. H. Davis of Rainfall previous to great floods on River Teme.

				in.
1836.	November	28	...	·40
	,,	26	...	·15
	,,	27	...	·35
	,,	28	...	·79
	,,	29	...	·24
				1·93

				in.
1839.	July	26	...	·25
	,,	27	...	·07
	,,	28	...	·01
	,,	29	...	·65
	,,	30	...	1·50
				2·48

				in.
1852.	November	4	...	·42
	,,	5	...	·29
	,,	6	...	·28
	,,	7	...	·40
	,,	8	...	·18
	,,	10	...	·90
	,,	11	...	1·49
	,,	12	...	·43
				4·89

				in.
1886.	May	10	...	·14
	,,	11	...	·28
	,,	12[1]	...	2·23
	,,	13[1]	...	2·12
	,,	14	...	·01
				4·78

[1] Largest on two successive days in 56 years. Nearest to it in July 1834 (four days) 4·59 ins.

Rainfall at Ross.

Previous to great floods on the Wye.

				in.
1852.	November	4	...	·92
	,,	5	...	·40
	,,	6	...	·72
	,,	7	...	....
	,,	8	...	·32
	,,	10	...	·25
	,,	11	...	1·37
	,,	12	...	·69
				4·67

				in.
1853.	July	7	...	2·20
	,,	9	...	·40
	,,	10	...	·49
				3·09

				in.
1867.	March	17	...	·31
	,,	18	...	·26
	,,	21	...	·45
	,,	22	...	·10
	,,	23	...	·83
	,,	24	...	·08
	,,	25	...	·58
				2·61

				in.
1869.	December	14	...	·42
	,,	15	...	·72
	,,	16	...	·03
	,,	17	...	·87
	,,	18	...	·23
	,,	19	...	·93
				3·20

				in.
1872.	July	6	...	1·31
	,,	7	...	1·46
				2·77

				in.
1875.	November	5	...	·73
	,,	6	...	·04
	,,	7	...	·59
	,,	8	...	·03
	,,	9	...	·77
	,,	10	...	·65
	,,	11	...	·01
	,,	12	...	·48
	,,	13	...	1·19
				4·49

				in.
1876.	December	26	...	·47
	,,	27	...	·24
	,,	28	...	·19
	,,	29	...	·52
	,,	30	...	·76
	,,	31	...	·63
1877.	January	1	...	·10
	,,	2	...	·35
	,,	3	...	1·02
				4·28

				in.
1880.	October	25	...	·12
	,,	26	...	1·27
	,,	27	...	·73
	,,	28	...	·11
				2·23

RAINFALL AT ROSS—*Continued.*

			in.				in.
1880.	December 27	...	·50	1894.	November 11	...	·19
	„ 28	...	·28		„ 12	...	·62
	„ 29	...	·44		„ 13	...	·83
	„ 30	...	·59		„ 14	...	·31
			1·81				1·95
			in.				
1886.	May 10	...	·18		Previous 19 days		5·44
	„ 11	...	·28				
	„ 12	...	1·70				
	„ 13	...	1·40				
			3·46				

COMPARATIVE HEIGHT OF FLOODS AT DIFFERENT PLACES.

Ross.

Assuming the height of the late flood at Ross to have been 14 ft. 3 ins. above lowest summer level of 1868, the following are approximate (say within an inch or so) comparative levels of highest reached, ranged in order, from greatest downwards:—

1770, November 18. No record, but said to be not quite equal to 1795 on Wye.

		ft.	in.			ft.	in.
1795	February 12	17	9	1877	January 1–2	14	3
1809	January 27............	17	3	1881	February 11	14	3
1824	November 24	17	3	1880	October 29	14	3
1831	February 10	17	3	1875	November 15	14	3
1852	„ 8	16	10	1886	May 14–15	14	2
1852	November 12	16	2	1880	December 31	13	10
1894	„ 15	14	3	1878	November 12	13	9
1867	March 24	14	3	1872	July 8[1]	12	6
1869	December 19	14	3				

[1] Very high for Midsummer Flood.

For comparative heights of floods at Worcester, Gloucester, &c. see *Quarterly Journal*, Vol. XII., pp. 280–281.

Shrewsbury.

		ft.	in.			ft.	in.
1795	February 11	20	$3\frac{1}{2}$	1852	February 7	19	2
1770	November 18	19	$9\frac{5}{8}$	1852	November 15	18	6
1672	December 23	19	$7\frac{1}{4}$	1831	February 10	17	8
1869	December 20	19	4	1849	No date given..........	17	6

NOTE.—There are brass plates in house formerly occupied by Mrs. Davies, Frankwell, Shrewsbury.—Extract Shrewsbury paper.

Evesham.

		ft.	in.			ft.	in.
1848	October 1	14	3	1875	October 21	12	$7\frac{1}{2}$
1852	November 11	13	6	1875	July 21	12	$0\frac{1}{2}$
1882	October 25	13	0				

Orleton, Tenbury.

1770	Maximum known, probably a few inches above 1795	1836	Nov. 30, $32\frac{1}{2}$ ins. below 1795
		1815	$39\frac{1}{2}$ „ „ „
1795	Next	1821	Sept. 7, $42\frac{1}{2}$ „ „ „
1839	$24\frac{1}{2}$ ins. below 1795	1852	Nov. 13, $13\frac{1}{2}$ „ „ „
1809	$31\frac{1}{2}$ „ „ „		

FLOODS AT TEWKESBURY

Dyke's *History of Tewkesbury* mentions high floods on the Severn on July 19th, 1587, when a sudden inundation overflowed the meadows to such an extent that the inhabitants were compelled to leave the loaded carts behind them as they went to gather the hay; and so great was the accumulation of y that "the townsmen were constrained with pitchforks and long poles to

stand on the bridge of wood to break the cocks, lest the bridge should be carried away by the force of them." In 1610 there was another flood, and again in 1640, when there were no less than eight floods between Midsummer and Michaelmas. This was followed by most severe frost, October 11th to 24th, freezing up all rivers and brooks. On December 23rd, 1672, so great was the flood that the water came into the chancel of the Abbey Church, and was the highest the oldest inhabitant could then recollect. The years 1721 and 1722 were times for floods, and again in 1727, when there were no less than twenty. With respect to 1754, there is an entry as follows :—"In this year there were nineteen sheets of water, which stopped the town mills an hundred days." But in the year 1770 there seems to have been the highest on record. It reached its height on November 17th, for in Bennett's *Register and Magazine* we gather that a Mr. Havard embarked near the turnpike in the High Street by the Bear Inn, and made a voyage round the town, which took him three hours to accomplish. The south side of the chancel of the Abbey was then under water, and Dyke observes that "two houses near the mills were washed down." In 1789 there was another high flood, boats being employed on the long bridge to convey passengers over it. This flood was after the breaking up of a severe frost.

DISCUSSION.

Mr. G. J. SYMONS submitted the following extracts from the Report of the Usk Fishery Commissioners, having reference to floods in that river:—

1872. Floods have damaged passes at Aberbrân and on the Cynrig.

1875. Numerous weirs and passes carried away by the flood of July 14th. The July rain was never heavy, but steady, about ¼ inch per hour—began 9 a.m. on 13th, finished 6 a.m. July 14th, total 5¼ inches.—G. B. Gething.

1876. A violent flood in October carried the river over the fields, and on the water running off left millions of small fish dry on the meadows.

1877. Tremendous flood on November 11th.

Time of highest water.

Brecon	... ...	November 11th, 8 p.m.
Pontygoitre	... ...	„ 12th, 6.15 a.m.
Trostrey Weir	...	„ 12th, 7.50 a.m.

At Brecon 4 inches below 1875.

At Glarmsk above 1875, but 10 inches below a flood on January 24th, 1840.

At the forge mill, near Clytha, the water entered the upper floor, but it was 2 feet 9 inches below the great flood of February 16th, 1795.

At Usk the flood was the greatest for more than 50 years.

Miss E. BROWN, in a letter to the Secretary, gave the following particulars as to the depth of water in a well 100 feet deep at Further Barton, near Cirencester :—

1894—October 26th	... ...	10 ft. 4 ins.
„ November 2nd	... ...	37 ft.
„ „ 9th	... ...	37 ft. 5 ins.
„ „ 16th	... ...	52 ft. 1 in.
„ „ 23rd	... ...	40 ft. 11 ins.
„ „ 30th	... ...	30 ft. 6 ins.

This was exceeded in 1875, when 60 feet was registered on November 15th. No record was kept as far back as 1852; but on September 4th of that year 2·83 ins. of rainfall was measured (in a gauge 9 ins. diameter).

Mr. SYMONS put in a plea for the permanent marking of flood heights, and expressed a hope that any who might have the opportunity would endeavour to carry out this simple but important work.

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

November 21st, 1 94.

Ordinary Meeting.

RICHARD INWARDS, F.R.A.S., President, in the Chair.

CAPT. GEORGE WILLIAMS ATKINSON, 5 Manor Park, Lee, S.E.;
JOHN R. EYLES, 80 St. Mary Street, Weymouth;
VALENTINE EDWARD JOHNSON, M.A., South Grove, Alderley Edge;
JAMES LEMON, M.Inst.C.E., Lansdowne House, Southampton; and
JOSEPH MONKHOUSE, Gilcrux, Carlisle,
were balloted for and duly elected Fellows of the Society.

The following papers were read:—

"METHODS OF DETERMINING THE INFLUENCE OF SPRINGS ON THE TEMPERATURE OF A RIVER, AS ILLUSTRATED BY THE THAMES AND ITS TRIBUTARIES." By H. B. GUPPY, M.B. (p. 1.)

"SOME EFFECTS OF THE GALE IN THE HIGHLANDS OF SCOTLAND ON NOVEMBER 17TH AND 18TH, 1893." By ERIC S. BRUCE, M.A., F.R.Met.Soc. (p. 11.)

"HISTORY OF A WATERSPOUT." By ALFRED B. WOLLASTON. (p. 13.)

December 20th, 1894.

Ordinary Meeting.

RICHARD INWARDS, F.R.A.S., President, in the Chair.

THOMAS WILLIAM ALDWINCKLE, F.R.I.B.A., 1 Victoria Street, S.W.;
CAPT. C. W. ANDREW, The Terrace, Kennington Park, S.E.;
HAMAR BASS, M.P., 145 Piccadilly, W.;
GEORGE GROVE BLACKWELL, Jun., 15 Hillside Road, Wallasey;
WILLIAM NISBET BLAIR, Assoc.M.Inst.C.E., 23 West Hill, Highgate, N.;
HENRY HUGH BRETON, Portswood House, Southampton;
CHARLES BROWNRIDGE, Assoc.M.Inst.C.E., F.G.S., Town Hall, Birkenhead;
JOSEPH STONE BURBERY. Trent House, West Cowes, Isle of Wight;
WILBERFORCE COBBETT, Assoc.M.Inst.C.E., Fareham;
NELSON FREDERICK DENNIS, Assoc.M.Inst.C.E., West Cowes, Isle of Wight;
ERNEST JOHN ELFORD, Hill House Road, Norwich;
E. A. SANDFORD FAWCETT, Assoc.M.Inst.C.E., 1 Victoria Street, S.W.;
MAJOR LAMOROCK FLOWER, 12 Finsbury Circus, E.C.;
CHARLES GILBY, Guildhall, Bath;
ROBERT M. GLOYNE, Assoc.M.Inst.C.E., Town Hall, Eastbourne;
WASHINGTON LYON, 85 Asylum Road, Peckham, S.E.;
THOMAS MANSELL, F.R.M.S., St. Thomas's Hospital, S.E.;
REGINALD EMPSON MIDDLETON, M.Inst.C.E., 17 Victoria Street, S.W.;
GEORGE SHAW, 20 King Edward Street, E.C.;
WILLIAM JOSEPH HOWARD SMITH, Assoc.M.Inst.C.E., Carlisle;
ANDREW SOUTH, Hamilton Road, Ealing, W.;
GEORGE WALTER STEEVES, B.A., M.D., Parkfield Road, Liverpool;
THOMAS DAVID WILLIAMS, F.G.S., Egremont, The Ridge, Hastings;
EDWARD WILLIS, High Street, Eton;
JOHN WILLIS, Stansfield, Windsor; and
ERNEST WORRALL, 5 Beaconsfield Terrace, Seacombe, Liverpool,
were balloted for and duly elected Fellows of the Society.

MR. R. H. CURTIS and MR. F. GASTER were appointed Auditors of the Society's Accounts.

The following papers were read :—

"REPORT ON THE CLOUD NOMENCLATURE PRESENTED TO THE INTERNATIONAL METEOROLOGICAL COMMITTEE AT UPSALA IN AUGUST 1894." By ROBERT H. SCOTT, M.A., F.R.S. (p. 16.)

"FLOODS IN THE WEST MIDLANDS." By HENRY SOUTHALL, F.R.H.S. (p. 28.)

"METEOROLOGICAL OBSERVATIONS AT MOJANGA, MADAGASCAR, DURING 1892-1894." By S. C. KNOTT. (p. 21.)

CORRESPONDENCE AND NOTES.

Shadows in Fog.—During the fogs of November 1894 I noticed a very remarkable, tall, dark column before one of the gas lamps on Cranleigh Common. On examining the lamp, I found that the flame of the burner was diagonally across the lamp, *i.e.* end on to the corner wires ; and the flame having very little width, the shadow of the wire on the fog was a sharply defined dark column, only to be seen from one particular position. The burners in the other lamps being placed square with the sides of the lamps, the cross lights of the length of the flame prevented any shadow being formed. J. P. MACLEAR.

Mistiness of the Atmosphere in East Winds.—A proof of mist with East winds, although the sky may be apparently clear, appears to be afforded by the following fact :—When printing from a negative exposed to the western sky near the zenith with a West wind blowing, the desired effect was produced in 14 minutes. A few days afterwards the same negative, under exactly the same circumstances, but with an East wind, the sky being apparently as clear as in the first case, took over 20 minutes to print to the same depth. There must have been a haze in the sky inappreciable to the eye. J. P. MACLEAR.

Dry Snow in High Wind.—The gale on the night of January 12th, 1895, presented the features of a little blizzard. The fine snow was blown under the slates and tiles of nearly every roof in Cranleigh village, and found its way into the attics, doing much mischief to ceilings. In many cases, also, the snow was blown through crevices in windows and doors, and formed piles of snow inside. J. P. MACLEAR.

Great Variation of Temperature in 7 hours.—Mr. A. F. Bowker, in writing from Bannack City, Montana, on January 14th, 1895, says : "I have been here in the Rocky Monntains for about two months in the States of Colorado, Utah, and Montana, during which time I have experienced very favourable weather. We have not yet had more than six inches of snow here (6,000 feet above sea level). It is so dry that one does not feel the cold nearly so much as at a very much higher temperature. On December 27th-28th the temperature fell to 40° *below* zero Fahr., and on the following day, only 7 hours after, it was 45° *above*—or a variation of 85° in 7 hours; both are shade readings."

Southerly Bursters.—The Hon. Ralph Abercromby, in December 1892, gave to the Royal Society of New South Wales the sum of £100 to promote the study of Australasian Meteorology by offering prizes for essays upon particular phases of weather, and in rewards for special investigations. The subject chosen for the first essay was "The Southerly Burster," the prize being £25. This has been awarded to Mr. Henry A. Hunt, Second Meteorological Assistant at the Sydney Observatory. The essay, which is accompanied by numerous diagrams and illustrations of clouds, has been printed in the *Journal of the Royal Society of New South Wales*, Vol. XXVIII.

The weather conditions indicating the approach of the burster are described as follows:—

"The climatic conditions preceding a southerly burster are, first, a period of high temperature varying from three hours to three or more days, accompanied in the early part of summer, or towards its close, by wind from the West or North-west, and in the midsummer months generally from the North-east. In the early morning on the day of a 'burst' the sky is white, and hazy of aspect. As the hour of the outbreak approaches, there begin to accumulate in the south ball-shaped, cirro-cumulus or pilot clouds, and frequently, if electric disturbances are to accompany the squalls, heavy cumuli, thunder clouds, rise gradually in the south-west. An hour or so before the squall a heavy cumulus roll appears low down on the southern horizon. The interval between this appearance and the beginning of the gusts depends entirely on the velocity of the wind. Afar off this cloud roll appears most frequently due south, but sometimes south-south-west, or even south-west. It is sharply defined, dark on the edges, with lighter shades towards the centre. The roll is from 30 to 60 miles in length. Sometimes it appears singly; on other occasions there are a multitude of these formations heaped one above the other, with light cirrus below. Generally, if the burst is of the first order, it is followed by an overcast sky composed of nimbus, from which patchy rain descends.

"As the cloud roll approaches, it gradually loses its symmetrical aspect, and careful observation reveals a light cirrus fringe rising from underneath it in front, falling over the top, and trailing behind the advancing cloud. Up to this time the wind has been blowing with steadily increasing force from a Northerly direction, but at this stage it drops suddenly, and a profound calm prevails, broken only at intervals by a few fitful puffs. This state of things lasts for a varying space. If the southerly arrives during the heat of the day, it endures but a very short time; if at night, the calm is of no longer duration.

"Meanwhile the cloud roll is seen rapidly approaching, clouds of dust rise in the southern part of the city four miles away, and gather volume as they come, until they almost hide the city as viewed from Observatory Hill, while from immediately under the roll light clouds rush forward with great velocity, only to be thrown back over the top of it as they reach the front; the wind vane on the time ball tower flies to the South, and the wind reaches us on the ground a moment later, and in a few moments is blowing with the force of a gale."

The author deals with the burster in other colonies, and shows that it is intensified in New South Wales by geographical features, and that it is sometimes caused by monsoonal depressions. Bursters always result in a fall of temperature, the average fall being 18°·1. The greatest diminution of temperature takes place during the first hour, and the fall is most sudden when the burst comes at midday. The greatest fall on record was that registered on December 30th, 1891: at 1.50 p.m. the temperature was 97°5; at 1.55, after the change to south, it had fallen to 80°·3; and at 1.57 to 79°·7; and at 2.15 it had descended to 75°·0, being a fall of 22°·5 in 25 minutes.

Mr. Hunt traces different kinds of bursters, their rate of progress along the sea coast, and relation to general weather conditions. He also gives a detailed description of two bursters, with diagrams of weather before and after, and photographs of clouds, with full notes of cloud changes. From the records of the past 31 years it appears that the average number of bursters in each year is 32, the greatest being 56 in 1869; and the least 16 in 1890.

Cyclonic Precipitation in New England.—Some six years ago Prof. Winslow Upton examined the reports of the observers of the New England Meteorological Society for the 19 months, January 1885 to July 1886, with the view of investigating the distribution of precipitation in cyclones. He has recently continued the discussion from August 1886 to December 1892, and finds that the results confirm his previous conclusions. The most important results are:—

1. The precipitation is sometimes along the path of the cyclone, but in the majority of cases the greatest amount is found many miles away from the path. These maximum areas are at the right or left, or on both sides of the path. The situation of the observing stations is more favourable to showing the maximum areas at the right of the paths of storms which come to New England from the west, and at the left of those which come from the south; hence these pre-

dominate in the cases examined. There is a larger proportion of cases in which the greatest precipitation lies along the track in southern than in western cyclones, and the distances are less in the former class when the maximum area is displaced.

2. The precipitation area does not maintain a constant position with regard to barometric centre of the storm, while the storm is in transit over New England. While departures from regularity are evidently to be expected in the curve of the rain front and rear as the precipitation area passes over country of varied topography, there seems to be a marked agreement between both rain front and rear in showing a different average rate of progression across New England than that of the barometric centre. In a few cases the rate of the rain front and rear is more rapid than that of the centre, but in the great majority of storms examined the rate was very much less. In other words, the barometric centre is usually displaced forward in the precipitation area while the cyclone is crossing New England.

Aberrations of Audibility of Fog Signals.—The U.S. Hydrographic Office in the *Pilot Chart* for November 1894 directs attention to the uncertainty of audibility of fog signals, and quotes the following examples furnished by Mr. A. B. Johnson of the U.S. Lighthouse Board.

The idea that sound is always heard in all directions from its source according to its intensity and force, and according to the distance of the hearer from it, is an erroneous popular notion. Instances of this fallacy have accumulated, and they are emphasised by shipwrecks caused by the insistance of mariners on the infallibility of their ears, who have accepted unquestioned the guidance of fog signals as they do that of lighthouses during clear weather. Audition is subject to aberrations, and under circumstances where little expected. Implicit reliance on sound signals often leads to danger if not death.

The steamer *Rhode Island* was wrecked in a fog on Bonnet Point, R.I., November 6th, 1880. Investigation showed that Beaver Tail Point fog signal (about 2 miles distant) was in full operation, and also proved that while there was no lack in the volume of sound emitted, there was often a decided lack in the audition of that sound. It could not be heard at the intensity expected, nor at the place expected; it would be heard faintly where it ought to be heard loudly, and *vice versâ*; it could not be heard at some points, while it could be heard further away; it could be heard and lost, and heard and lost again, all within reasonable earshot, and all this while the signal was in full blast and sounding continuously.

On the night of May 12th, 1881, the *Galatea* grounded in a dead calm and dense fog on Little Gull Island, Long Island Sound, about one-eighth of a mile from the fog signal. Investigation by the officers of the Lighthouse Board proved that the fog signal was in operation, it having been heard 15 miles distant at Mystic, Conn. Several days were spent steaming about Little Gull Island, and the aberrations in audition here were as numerous and eccentric as at Beaver Tail.

Gen. Daune, U.S. army, in a report to the Lighthouse Board, states, regarding the action of six steam fog signals on the coast of Maine, that they have frequently been heard 20 miles distant, and again not heard at a distance of 2 miles. The whistle at Cape Elizabeth was heard at Portland, 9 miles away to windward, during a heavy North-east snow storm, the wind blowing a gale at the time. The greatest difficulty observed, he says, arises from the fact that the signal appears to be surrounded by a belt varying in radius from 1 to 1½ miles, from which the sound appears to be entirely absent. This action is common to all ear signals, and has been observed at all stations, even one on a rock 20 miles from the mainland, with no surrounding objects to deflect the sound.

After carefully considering all publications and experiments on the subject, Mr. A. B. Johnson makes the following recommendations:—

"When approaching from windward, fog signals are likely to be heard earliest from aloft; from leeward on deck. Do not assume that you are out of hearing distance if the signal is not heard; nor that it is at a great distance because it is faint; nor near because it is plainly heard; nor that a given point of the course is reached because the signal is or is not heard with the same intensity as on some former occasion; nor that the signal has ceased sounding because it is

not heard within easy ear-shot; nor that the aberrations of audibility are the same in different fog signals. Do not expect to hear the signals so well when the upper and lower air currents are moving in opposite directions; or when wind and tide are contrary; or during electrical disturbances; or when the sounds must come over an island or point of land. When a bluff exists behind the signal, be prepared for irregular intervals in audition, such as would follow were the sound to ricochet as a cannon ball. Thus, you might hear it at 2, 4, 6, 8, etc., miles, and lose it at 1, 3, 5, 7, etc., miles, or at any other combination of distances, regular or irregular. When expected signals are not made, keep the lead going freely and proceed carefully."

Climate of Corsica.—Mr. R. Richardson, in the *Scottish Geographical Magazine* for October 1894, gives some particulars about the climate of Corsica. After referring to a pamphlet published by Mons. C. Guérin, formerly a meteorological observer at Ajacco, he says: M. Guérin makes the somewhat remarkable statement that, after numerous observations in years which were reported rainy, only 50 days on an average per annum were recorded at Ajaccio during which the sun did not shine. He adds that most rain falls during the autumnal equinox towards the close of September, less rain falling during the vernal equinox. As to winds, the worst are the Libeccio (South-west) and the Mistral (North-west), whilst the East wind and South-east wind (Sirocco) are extremely hot. M. Guérin declares, after a long experience, that there are really only two seasons at Ajaccio, one warm and dry, from May to September; the other genial and temperate, from October to the end of April. The temperature in winter is more constant than on the Riviera, where the icy wind from the Alps makes more victims than is generally supposed. Again, the air of Ajaccio is more salubrious for invalids than that of Algiers, where the summer is scorching, and winter, owing to the vicinity of the Atlas range, more trying than in some towns in the centre of France.

The fact is that we must remember, in comparing Corsica with the Riviera or Algeria, that Corsica is an island, and therefore much more exposed than they are to marine influences. Whilst these marine influences temper heat, they also prevent cold winds from having their icy character which a passage in winter over land alone is apt to entail.

The average temperature and rainfall at Ajaccio are as follows:—

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Temp.... ...	51·0°	51·3°	52·5°	58·[illegible]°	63·3°	70·8°	75·3°	77·2°	71·8°	63·6°	56·8°	51·8°	62·0°
Rain	2·39	1·69	1·94	2·07	1·55	0·72	0·15	1·07	1·01	2·81	4·96	2·40	22·76

The climate of Corsica, as a rule, is healthy, except on the east coast and near marshes at the mouths of rivers. To overcome the malarial atmosphere at such places, eucalyptus trees have been planted along the roads traversing them. Both Dr. Bennet and Miss Gertrude Forde agree that the best time to visit Corsica is during spring. "The climate," says the latter, "is delicious in early spring, and the flowers and trees are in their glory in April and May. The lowland towns become hot and unhealthy for visitors in June, if not before. The east coast of the island is to be avoided by travellers, being rife with malarious fever."

Temperature of the Earth's Crust in the Sahara.—Mons. Georges Rolland has made a communication to the Académie des Sciences on the rise of temperature with the depth, as ascertained by observations in artesian wells, mines, &c. About 1° F. for every 53 feet is the usual increase of temperature below the level of constant temperature, but in the Sahara the rise is much more rapid. In the Wed Rir the temperature of the subterranean reservoirs has been found to be from 73°·4 to 80°·2, and the mean of the most reliable observations along the principal artery is 78° for an average depth of 246 feet. It may be estimated, according to MM. E. Renou and L. Teisserenc de Bort, that the stratum of constant temperature lies at a depth of about 65 feet, and that its temperature is 71° to 78°. Thus the difference of level between the stratum of no variation and the great reservoir of the Wed Rir would be about 180 feet, and the difference of temperature 6°, and consequently the rate of increase about one degree for every 30 feet. Further south, at Wargla, M. Rolland's observations indicated a

yet more rapid rise. It is true that these observations apply only to the water in the wells, but M. Rolland believes that, under the actual conditions, the temperature of the wells of the Sahara may be taken to be that of the surrounding strata. In conclusion, M. Rolland affirms that in many parts of the Sahara, between lat. 33° and 35°, the temperature of the ground really rises with the depth in the ratio of not less than one degree to 35 feet, and often more rapidly; but he does not consider that so high a variation of temperature inversely to the latitude can be inferred, as a comparison with observations in Europe would give. —*Scottish Geographical Magazine.*

RECENT PUBLICATIONS.

American Meteorological Journal. October-December 1894. Vol. XI. Nos. 6-9. 8vo.

The principal articles are :—The Meteorological Services of South America II.: by A. L. Rotch (10 pp.). In this paper the author gives an account of the meteorological organisations in the Argentine Republic; Uruguay and Brazil.—The forecasting of Ocean Storms, and the best methods of making such forecasts available to commerce : by W. Allingham (10 pp.). This is the reprint of a paper read at the International Meteorological Congress at Chicago in August 1894.—Sunspots and Auroras : by Prof. H. A. Hazen (7 pp.).—Cyclonic Precipitation in New England: by Prof. W. Upton (30 pp.).—The barometer at Sea: by T. S. O'Leary (8 pp.).—Psychrometer Studies : by Dr. N. Ekholm (8 pp.).—Meteorological records obtained in the upper air by means of kites: by H. H. Clayton (6 pp.). This paper describes some experiments and observations made by Mr. W. A. Eddy by means of kites at the Blue Hill Observatory. Among other interesting results were the following :—On July 31st, 1894, the kites were let up at noon in a sea breeze. When the kites had risen about 400 feet above the hill the topmost kite veered around from the west, thus giving the depth of the sea breeze as 1,000 feet above sea level. During the afternoon the sea breeze steadily increased in depth, and veered towards the south. On August 6th, during the prevalence of light winds from the West, an effort was being made to elevate the kites, which refused to remain permanently in the air, since the air movement was not sufficient to sustain the heavy kites employed. But at 2.20 p.m., while a 5 foot kite was being maintained at a short distance above the hill by means of sundry jerks and pulls, a rather large cumulus cloud approached the zenith, and suddenly the kite began to ascend almost vertically. Cord was rapidly let out, and in a short time the kite was flying directly overhead, and continued to rise until all the available cord had been let out. It followed the cumulus for a short distance beyond the zenith, then rapidly dropped to the earth. Mr. Eddy afterwards measured the length of cord out and reported 1,172 feet, which must have been approximately the altitude of the kite, since the cord hung almost vertically under it. This seems to furnish striking evidence of the existence of ascending currents under the cumulus clouds. The kites also at times gave evidence of great aerial eddies around and above the hill, which swayed the kites from side to side.—Meeting of the International Meteorological Committee : by A. L. Rotch (7 pp.). This is an account of the proceedings at the Meetings of the Committee held at Upsala, August 20th to 24th, 1894.

Annuaire de la Société Météorologique de France. April-September 1894. 4to.

The principal papers are :—Sur l'origine des orages et des perturbations atmosphériques : par J. R. Plumandon (7 pp.).—Recherches pratiques sur la photographie des nuages : par G. Raymond (7 pp.).—Influence réelle des eaux sur la température : par M. Bouvet (4 pp.)—Sur le régime des pluies dans le Canal de Suez : par A. Angot (4 pp.). The author has tabulated the rainfall at Port Saïd, Ismailia, and Suez, the records extending over 17 years, viz. 1866-68 and 1880-93. The mean monthly results are :—

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Port Said... ...	·88	·47	·39	·27	·03	·01	—	—	·03	·27	·24	1·03	3·62
Ismailia	·47	·33	·29	·15	·16	—	—	—	—	·17	·08	·40	2·05
Suez	·24	·09	·08	·16	·21	·01	—	—	·01	·03	·07	·12	1·02

Prévisions sur la tenue des sources et des eaux courantes dans le bassin de la Seine pendant l'été et l'automne 1894 : par G. Lémoine (2 pp.).—Résumé des observations météorologiques faites à l'Observatoire de la Tour Saint-Jacques en 1891, 1892, et 1893 : par J. Jaubert (22 pp.).—Trombe dans le Calvados, 6 Juin 1894 : par G. Guilbert (2 pp.).—Observations météorologiques faites au cours d'une mission dans le pays des Touareg Azdjer, Octobre 1893-Mars 1894 : pars F. Foureau (10 pp.).

Cloudland ; a Study on the Structure and Characters of Clouds. By Rev. W. Clement Ley, M.A., F.R.Met.Soc. 1894. 8vo. 208 pp. and 6 plates.

This work has been very well got up, and is illustrated with numerous coloured plates, photographs, charts, and diagrams. The author has been a life-long observer of clouds, and he here sets forth the results of his experience and proposes a new classification and nomenclature of clouds. The list comprises 27 separate forms, which are arranged as follows :—

Clouds of Radiation.

Nebula—Fog. *Nebula Stillans*—Wet Fog. *Nebula Pulvera*—Dust Fog.

Clouds of Interfret.

Nubes Informis—Scud.
Stratus Quietus—Quiet Cloud.
Stratus Lenticularis—Lenticular Cloud.
Stratus Maculosus—Mackerel Cloud.
Stratus Castellatus—Turret Cloud.
Stratus Præcipitans—Plane Shower.

Clouds of Inversion.

Cumulo-rudimentum—Rudiment.
Cumulus—Heap Cloud.
Cumulo-stratus—Anvil Cloud.
Cumulo-stratus Mammatus—Tubercled Anvil Cloud.
Cumulo-nimbus—Shower Cloud.
Cumulo-nimbus Grandineus—Hail Shower.
Cumulo-nimbus Nivosus—Snow Shower.
Cumulo nimbus Mammatus—Festooned Shower Cloud.
Nimbus—Rainfall Cloud.
Nimbus Grandineus—Hail-fall.
Nimbus Nivosus—Snow-fall.

Clouds of Inclination.

Nubes Fulgens—Luminous Cloud.
Cirrus—Curl Cloud.
Cirro filum—Gossamer Cloud.
Cirro-velum—Veil Cloud.
Cirro-velum Mammatum—Draped Veil Cloud.
Cirro-macula—Speckle Cloud.

The author describes each of the above forms, and gives an account of their formation.

As observations of the direction of *Cirrus* are held to be of service for forecasting purposes, the following rules by the author may be considered useful and instructive :—

"*Cirrus* moving from North or North-east with a high barometer is a sign of settled weather in summer and of temporarily fine weather in winter. With a low barometer it is a sign of marked improvement in weather.

"*Cirrus* moving from East, a rare occurrence, is a sign of fine weather in winter, but of unsettled weather in summer.

"*Cirrus* moving from South-east (but it rarely does so with a low and unsteady barometer) is a sign of improving weather in winter, and in summer frequently indicates coming thunderstorms.

"*Cirrus* moving from South is generally an indication of unsettled weather, especially in summer. The temperature is then usually above the mean for the time of year.

"*Cirrus* from South-west indicates unsettled and sometimes stormy weather in winter. In summer it often precedes thunderstorms, but with a high barometric pressure and a high temperature it frequently has no disturbing influence, and is then usually replaced by *Cirro macula*.

"*Cirrus* from West is commonly in summer a symptom of fair weather, but it is less so in winter.

"*Cirrus* from North-west, when not tending to the form *Cirro filum*, is an indication of temporary fine weather, especially in summer."

Mr. Ley also devotes chapters to the theory of atmospheric currents ; the prevailing winds of the globe ; cyclones and anticyclones and their cloud-forms ; and prevalent cloud-forms of the globe.

In conclusion, the author urges the preparation of a set of typical weather charts for each distribution of elements, showing isobars, winds, and weather, including cloud-forms and upper currents. Each chart should be numbered and printed on the left page of a large book, and on the opposite page a short description of probabilities of general changes should be given in reference, more especially, to the season of the year. If these charts were plentifully distributed over the country, at sea ports, &c., all that the central office need do would be to wire simply the number of the page, when any one who turns to the chart indicated would know at once what weather to expect.

Meteorologische Zeitschrift. Redigirt von Dr. J. Hann und Dr. G. Hellmann. October and November 1894. 4to.

The principal contents are:—Einige Ergebnisse wissenschaftlicher Fahrten des Münchener Vereines für Luftschiffahrt: von S. Finsterwalder und L. Sohncke (16 pp.). These ascents are particularly interesting, from the proximity of Munich to the mountains, where there are several high level stations. The result of all the temperature observations is to show that in the free atmosphere, as compared with mountain stations, the temperature is lower by day and higher by night, so that the range at the mountain stations is greater than in the balloon. The next point investigated was the evidence of unstable equilibrium preceding thunderstorms. Of this, five cases came under observation. The other subjects discussed are the inversion of temperature on warm nights in summer ; the decrease in aqueous vapour with height ; and the development of stratification in the atmosphere. On the whole, the results agree very satisfactorily with the theoretical deductions of Dr. Hann.—Einige Bemerkungen über die Anwendung der Photogrammeter zur Messung von Wolkenhöhen : von N. Ekholm (5 pp.). This is a correction of some statements contained in a pamphlet by Dr. Åkerblom, issued at Upsala last summer.—The November number is entirely occupied by three papers by Dr. A. Woeikof, at least as far as the printing in large type extends. The first paper is on the dependence of rain upon changes in the sectional area of air currents. The author seeks to prove that the stronger the winds the less rain falls. The second paper is on the daily range of temperature and hydrometeors in Northern India. He finds that there are three types as regards relative humidity, viz.—1. Minimum at sunrise, and maximum in afternoon or evening. 2. Double period: two maxima in the late morning and evening, and two minima in the early morning and the afternoon. 3. Maximum in the morning and minimum in the afternoon. He gives the stations coming under each class, and proceeds to explain the causes of the difference. The third paper is on the rainfall of the south-west of the Caucasus.

Meteorology, Practical and Applied. By John William Moore, B.A., M.D. Sanitary Series, No. 1. 1895. 8vo. 445 pp.

This book is divided into four parts. The introduction is followed by an account of the methods which are employed in practical meteorology. A large portion of this, however, 68 pages in all, is devoted to the history, work, and publications of the U.S. Weather Bureau. The third part treats of climate and weather. In the fourth part some of the practical bearings of the subject are pointed out. The author also discusses the question of the influence of weather and season upon disease. The work is copiously illustrated with engravings of instruments, &c.

Proceedings of the Australasian Association for the Advancement of Science. 1894. 8vo.

Among the papers read before the Association was "Meteorological Work in Australia: a Review," by Sir C. Todd, F.R.S., which gives a brief and succinct account of meteorological work in Australia. Sir C. Todd traces the history of the meteorological organisations in New South Wales, Victoria, South Australia, Western Australia, Queensland, Tasmania, and New Zealand ; and also describes the present condition of meteorological science. With regard to South Australia, the three principal weather conditions are :—1. A continual series of

anticyclonic areas, which in the winter pass over the interior, covering the whole or greater part of the continent, with gradual falling gradients from the centre, while in the summer they pass along or near the south coast. 2. Cyclones, disturbers of the peace, but bringing fruitful rains; sometimes, alas! disastrous floods. These are mostly of tropical origin, and, starting on a west to southwest course, they re-curve south of the trade belt, and move to the south-east. Some—those approaching from the north-east of Australia—strike the east coast of Queensland, others enter by the Gulf of Carpentaria, and passing inland, shed rains over the western interior of Queensland and New South Wales; others pass over the interior from the north-west; whilst others again pass to the west of Australia, and ultimately, rounding the Leeuwin, appear as a south coastal disturbance. 3. Northerly extensions of the antarctic low pressure, which passing along the south coast, give winter rains, and, on their retreating side, south-westerly gales.

Report on Meteorological Observations in British East Africa for 1893. By E. G. RAVENSTEIN, F.R.Met.Soc. 1894. 8vo. 12 pp.

This Report, which is published by authority of the Directors of the Imperial British East Africa Company, gives a summary of the meteorological records kept at Chuyu, Mombasa, Malindi, Magarini, Lamu, Witu, and Kisimayu, on or near the coast, and at Machakos and Fort Smith in Kikuyu in the interior. The rainfall appears to decrease very rapidly northward along the coast. Mr. Ravenstein believes that the mean annual rainfall is as follows:—Mombasa, 51 ins.; Malindi and Jilori, 45 ins.; Magarini, 39 ins.; Lamu, 37 ins.; and Kisimayu, 11 ins.

Symons's Monthly Meteorological Magazine. October-December 1894. Vol. XXIX. Nos. 345-347. 8vo.

The principal articles are:—Protection from Lightning (2 pp.).—The recent Drought in the Midlands: by Rev. G. T. Ryves and Rev. T. A. Preston (5 pp.).—Enormous Hailstones (3 pp.). On August 26th, 1894, a number of violent thunderstorms occurred in the north of France and in Belgium, and were accompanied by hail of great size. It is reported that many of the hailstones weighed 7 oz. At Blancfosse, Oise, some of the hailstones weighed 10½ oz.; at Beaucourt hailstones were picked up weighing nearly 2 lbs.; while at Mézières one which came through a window and broke a workbox is stated to have weighed 2 lbs. 10 oz.! Sheep, birds and game were killed by the hailstones.—Rainfall at Jerusalem (4 pp.). From observations extending over the 32 years, 1861-1892, it appears that the average monthly rainfall at Jerusalem is as follows:—

	Rain. in.	No. of Days.		Rain. in.	No. of Days.
January ...	6·38	12	July ...	·00	0
February ...	5·06	10	August ...	·00	0
March ...	3·56	8	September ...	·04	0
April ...	1·71	5	October ...	·41	2
May ...	·27	2	November ...	2·29	6
June ...	·01	0	December ...	5·50	10

The yearly total is 25·23 in., with 55 rainy days.

The mean rainfall is almost identical in total with that in London, but no rain falls between May and October, and about a fifth of the yearly total falls in each of the three months, December, January, and February.—Storm of September 20th, 1894, at Martinique (2 pp.).—The Floods of November 1894 (10 pp.).

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WEATHER FALLACIES.

An Address delivered to the Royal Meteorological Society, January 16th, 1895.

BY RICHARD INWARDS, F.R.A.S.,

PRESIDENT.

IN the long and patient pursuit which the attainment of all accurate knowledge exacts from man, it may sometimes be instructive to turn one's gaze backward and contemplate the errors which have been corrected, the fallacies which have been demolished, and the superstitions which have been lived down; and this consideration has prompted me to take for the subject of this year's Address that wide range of human opinions which may fitly be classed under the head of "Weather Fallacies."

Nothing could have been more in accordance with the law of growth in other branches of knowledge than that Meteorology should, in its earliest dawn, have been with difficulty able to emerge from the mists and darkness of guesses and surmises such as have surrounded the transfer of any truth from the barbaric to the philosophic stage.

It is to the Greeks that we must look for the first real weather observations after the matter had passed through what may be called the mere savage phase; and we find Hesiod, Theophrastus, and Aratus presenting us with an early code of rules, which serve at least to show us how little we have ourselves advanced in some matters since their time.

One of our Fellows, Mr. J. G. Wood, has just given to the world an excellent and scholarly translation of the work of Theophrastus, which has not previously been put in an English garb, and Mr. Wood has done the whole country a great service in giving us this translation of the *Winds and Weather Signs*, a book which contains a host of rules and observations about the weather, and which, as might have been expected from the production of the favourite pupil of Plato and Aristotle, is singularly free from errors of the grosser and more superstitious kind, such as were plentifully produced in Western Europe many centuries later.

But long before the time of Theophrastus, and probably very soon after the invention of agriculture itself, there were weather gods and weather fallacies; for we find that Jupiter Tonans and Pluvius—the thunderer and the rain maker—were set by men on the highest pedestals. And centuries after this, Lucian tells us that it was usual in his time to offer prayers for suitable weather, and he recounts in his *Dialogues* how two countrymen were at the same time offering up contrary petitions,—one that not a drop of rain might fall until he had completed his harvest, while the other prayed for immediate rain, in order to bring on his backward crop of cabbages,—both suppliants only too sure to find that the ears of the image were deaf as the stone of which they were made, and that the wheels of the universe would not wander or turn back for any selfish ends of man.

In considering these early times when the weather had to be studied from cloud, sky and sea, and from the behaviour of the animals and plants, we must be ready to excuse men for doing that which is still too frequently a cause of error, viz. foretelling what they most wished for, and putting down as universal law that which was only a coincidence of totally independent events. In considering weather fallacies it will be impossible to follow a chronological order, so I shall treat them, or rather a small portion of them, under the heads of saints' day fallacies, sun and moon fallacies, and those concerning animals and plants, while finally I shall consider the almanack makers, weather prophets and impostors who have from time to time furnished the world with materials for its credulity or its ridicule.

The first class of weather fallacies which I shall scarcely more than mention, are those which refer to the supposed connection between the weather of any day in the week or year, and that of any other period, and it may be as well to state at the outset that there is no kind of foundation in fact for any of these so-called rules. They are for the most part born of the wish to see certain kinds of weather at certain times of year, and, like all these predictions, were faithfully remembered when they came true, and promptly forgotten when they failed. One has often heard—

"Fine on Friday, fine on Sunday,"

Or that "Friday is the best and worst day of the week," and the superstition even extends to hours of the day, for we have—

"Rain at seven, fine at eleven,"

which is only another way of saying that rain does not usually last four hours, and the rule generally fails when applied to daily experience, but the host of proverbs connected with saints' days are more difficult to deal with, on account of the longer time which elapses between the prophecy and its fulfilment or failure. All or most of these proverbs concern the days of certain saints, though I think no one imagines that this is anything more than a convenient method of fixing the date, because our ancestors had a saint for every day, so that they naturally referred to the day by his name.

There are forty weather saints, among the most prominent of whom is undoubtedly St. Swithin, whose day is July 15th, and the superstition is that if it should rain on that day it will rain for 40 days after. Now, as Mr. Scott observes, this date is very near a well known bad time in wet years, as the terms, long in use, of "St. Margaret's flood" and "Lammas flood" abundantly testify. The fact that some of these heavy rains began on July 15th has been enough material for the adage-monger, and so we have another "universal" law laid down, a law which is, however, constantly broken, as every student of the weather very well knows. The whole thing is a fallacy of the most vulgar kind, and ought speedily to be forgotten, together with all the adages which make the weather of any period depend on that of a distant day.

Turning in weariness from this class of superstitions, which may be said to belong to the self-exploding order, we are next met by an extensive array of authorities who, under the protecting shield of astronomy, profess to have framed infallible rules for the weather as judged from the ever-varying relative positions of the sun, moon, and planets. They attack us systematically and persistently, appealing to analogy, to reason, and to common sense. But it is sometimes necessary to be on our guard, even against common sense, in considering problems to which uncommon sense has for centuries been devoted without avail. The well-known action of the sun and moon upon the ocean tides is generally the starting point of these theorists, and it is soon shown to common sense that when the earth is nearer the sun, or the moon is nearer to the earth (it being remembered that they move in elliptic orbits), or when both sun and moon are, as it were, pulling together, as at new moon, there ought to be a tide of atmosphere caused by their influence similar to the tides of the ocean, which such agencies undoubtedly produce. But we find that whatever so-called reason, analogy, and common sense may seem to dictate, the facts will not follow in the path marked out for them; and the atmospheric tides refuse to ebb and flow, except in a most infinitesimal degree, quite disproportioned to their supposed moving forces. The theorists must try again, and they do so by pointing out that the moon and earth move in planes which are inclined to each other at an angle, and that at some times of the year the attraction of the sun and

moon are acting in somewhat widely diverging lines, whilst at others they are pulling more nearly in the same plane. Here is, they say, a clear case. At times, when the angle is greatest, there should at any rate be worse weather caused by the conflicting forces. When the moon is said to be "on her back," or, in other words, when the line of the shadow boundary of the half-moon or crescent is much inclined to the earth's axis, then is the time, say they, for tempests and commotions to come. But again the spirits from the "vasty deep" do *not* come when called, and we have to invent other causes for our earthly disturbances.

It may be safely said that a new moon theory as to the weather comes out at least once a year, and it has been attempted to connect the honoured name of Sir William Herschel with a table which professed to show the dependence of weather changes on those of the moon.

By the kindness of Mr. Symons I am able to show you on the screen a much magnified representation of this production, now very scarce, and which has the name of Herschel in large capitals, no doubt as a sort of ballast to give it weight and steadiness, though it does not definitely state that Herschel had anything to do with it. Herschel's own letter on the subject runs as follows:—

Sir

I am glad of an opportunity to say that prognostications of the weather are so much above the knowledge of astronomers that I have taken uncommon pains publicly to contradict reports of predictions that have been ascribed to me. You may therefore be assured that what you have heard as my opinion about the frost is without the smallest foundation. If at any time Slough should be in your road, I shall be very glad to see you here, and remain

Sir your most Obedt
Servt
Wm Herschel

Slough
near Windsor
Feb 6. 1814.

So that any Fellow of this Society who sees one of these diagrams in the future will know that it is a fraud.

Of course it is in the power of every one to check the predictions which are so often issued with respect to the changes of the weather taking place at the change of the moon; but many eminent men have occupied them-

selves with the subject, and the result is that no correspondence between the two classes of phenomena has been established.

Dr. Horsley examined the weather tables of 1774, as published by the Royal Society, and out of 46 changes of weather in that year only 10 occurred on the days of lunar influence, only two of them being at the new moon, and none at all at the full. M. Flarguergues, of Viviers, found also as the result of 20 years' observations, that the barometer readings taken when the moon was furthest from the earth averaged 755 millimetres, and when nearest, 754 millimetres, showing a difference of 1 millimetre or about ·04 inch, and this in a direction against the theory, the pressure being greater by that amount when the moon was farthest from the earth.

Various other weather seers have pinned their faith on lunar cycles, and have predicted that weather changes would repeat themselves, as soon as the sun and moon got back into the same relative positions, which they do in 19 years, with only an error of an hour and a half. Others, such as Mr. G. Mackenzie, advocated a cycle of 54 years, but it may be summarily stated that all the cycles have broken down, and that, as far as we know, there is no definite period after which the weather changes repeat themselves.

Other fallacies about the moon are numerous, such as that the full moon clears away the clouds; that you should only sow beans or cut down trees in the wane of the moon; that it is a bad sign if she changes on a Saturday or Sunday; that two full moons in a month will cause a flood; that to see the old moon in the arms of the new brings on rain, and many others, of which a catalogue alone would take up a good deal of space. M. Flammarion says that "the moon's influence on the weather is negligible. The heat reaching us from the moon would only affect our temperature by 12 millionths of a degree; and the atmospheric tides caused by the moon would only affect the barometric pressure a few hundredths of an inch—a quantity far less than the changes which are always taking place from other causes." On the whole we are disposed to agree with the rhyme which thus sums up the subject:

> The moon and the weather
> May change together;
> But change of the moon
> Does not change the weather.

Even the halo round the moon has been discredited, for Mr. Lowe found that it was as often followed by fine weather as by rain, and Messrs. Marriott and Abercromby found that the lunar halo immediately preceded rain in 34 cases out of 61. We always have a lingering hope that some future meteorologist will disentangle the overlapping influences, and arrive some day at a definite proof that our satellite after all has something to do with our weather.

About the sun, also, there are many fallacies, and ever since the discovery that the spots which appear on his surface have a period of greatest and least frequency, there have been theorists in shoals who have sought to prove that this fact rules our weather. It has undoubtedly been found that the

frequency of sun spots and the variations of the magnetic needle are intimately connected; and it is almost equally well established that the aurora appears and disappears in some sort of sympathy with the sun spot variations. But this, up to the present, is as far as we can get in this direction, for our weather seems to have no relation whatever to these changes.

The more recent discoveries of prominences visible round the disc of the sun during an eclipse, and of the light clouds only seen in M. Deslandres' spectro-photographs, will no doubt call out new weather theories on the subject. And I must confess to a wish that those mysterious flame-like bodies rushing from the sun millions of miles into space, will be found to have some influence on the upper layers of our earth's atmosphere; but I also hope that we may be saved from a theory on the subject until more facts are before us.

Coming down to earth again, we are met by a long array of fallacies connected with the behaviour of animals and plants, and which have a supposed connection with weather changes. Few of these are so well grounded that they may be considered as proved, and as nothing is sacred to a meteorologist, our veteran Fellow, Mr. E. J. Lowe, F.R.S., has endeavoured to put some of the rules from this source to the test of definite observation. He took a number of well known signs said to indicate change, and carefully noted what happened after each sign, and although he does not say that all indications from animals, birds and plants are useless, yet certainly those he did investigate seemed utterly to break down.

He took the well-known signs of bats flying about in the evening, many toads appearing at sunset, many snails about, fish rising much in lake, bees busy, many locusts, cattle restless, landrails clamorous, flies and gnats troublesome, many insects, crows congregating and clamorous, spider-webs thickly woven on the grass, spiders hanging on their webs in the evening, and ducks and geese making more than usual noise. Mr. Lowe found that in 361 observations of the above signs, they were followed 213 times by fine, and only 148 times by wet weather; so that even after the prognostications for rain, there was a greater preponderance of fine weather. He called a day fine when no rain was measurable in the rain gauge. Mr. Lowe says that even swallows flying low cannot be depended on, as, especially at the close of summer and autumn, they almost invariably skim the surface of the ground, and Mr. Charles Waterton, the naturalist, decided, after careful observation, that the unusual clamour of rooks forms no trustworthy sign of rain. These must, therefore, swell the list of fallacies, although there are many other rules which have not been so carefully examined, but which may still be true. My own impression is that although it is painful to dismiss the animals from their ancient position as weather prophets, we may consider them as indicating what they feel, rather than as predicting what is to come, and that their actions before rain simply rise from the dampness, darkness or chilliness preceding wet weather, and which render these creatures uneasy, but not more so than they affect man himself. The sheep turning its back to the wind (one of the best known signs of rain) is probably only

that it may shelter its least protected part from the effects of the weather; and many of you must have observed sheep sheltering their heads from the heat by getting them into the shade of each other's bodies in a similar way.

As to cows scratching their ears, and goats uttering cries, and many other signs of bad weather, they are at least very doubtful; whilst the adage about the pig which credits him with seeing the wind, carries with it its own condemnation.

The medicinal leech is still left on the list of weather prophets, though he has no doubt had his powers exaggerated; and two books have been written about his behaviour during changes of weather. One is by Mrs. Woollams, who, during a long illness, watched a leech in a bottle, and carefully noted what it did; and the other is by a gentleman at Whitby, who came to the conclusion that the leeches could be made to give audible and useful storm warnings. So he contrived the instrument, of which I now show you a drawing taken from his book. No one would imagine from its appearance what its use could be. It consisted of 12 glass bottles each containing a leech in water, and so arranged in a circle, in order, as the humane inventor states, that the leeches may see each other and not endure the affliction of quite solitary confinement—this rather reminds us of Isaac Walton, who told his pupil to put the hook into the worm "tenderly, as if he loved it"—in each bottle was a metal tube of a particular form, and which was made somewhat difficult for a leech to enter, but into which it would endeavour somehow to creep before a thunderstorm, according to its nature. In each tube was a small piece of whalebone, to which a gilt chain was attached, and so arranged, on the mouse-trap principle, that when the whalebone was moved the bell at the top of the apparatus was rung by means of the chain. There were 12 leeches, so that every chance was given that one at least would sound a storm signal. The author called this apparatus the "Tempest Prognosticator," a name which he preferred—and I think we shall agree with him—to that of atmospheric electric telegraph conducted by animal instinct. He went on to state in his little book that he could, if required, make a small leech ring the great bell of St. Paul in London as a signal of an approaching storm. The book is written in all seriousness, and a number of letters are appended from gentlemen who certify that correct atmospheric indications were at various times given by the leeches. The name of the inventor of this ingenious contrivance was Dr. Merryweather—himself a learned leech.

Plants have also their advocates as weather indicators; and there is no doubt that in most cases they act in sympathy with changes in the dampness, gloominess, or chilliness of the air, and as these conditions generally precede rain, one cannot term the indications altogether fallacious. The pimpernel and the marigold close their petals before rain, because the air is getting damper, while the poplar and maple show the under surface of their leaves for a similar reason. Indeed, an artificial leaf of paper may be made to do the same thing, if constructed on the same principle as the natural one—a hard thin paper to represent the upper side of the leaf, and a thicker unsized paper for the lower side; these will, if stuck together, curl up or bend down

in sympathy with the hygroscopic condition of the air. A slip of ordinary photographic paper will do the same, and will curl up at once when placed on the hand.

The same slackness which moisture produces in plants applies in some degree also to insects, some of which can only fly in sunshine, so that there is a chain of weather signs all following from a little dampness in the air. The flowers close their petals and shut in their honey, the insects cannot fly so high, and the swallows seeking them skim the surface of the earth, and even then the threatened shower may not come.

In 1892 attention was directed to a plant, the *abrus precatorius*, a beautiful shrub of the mimosa kind, which has the property of being sensitive in a high degree, so that its pinnate leaflets go through many curious movements, and it was claimed that these form a guide of unerring certainty to foreshow the coming weather. Even earthquakes were said to be predicted by this wonderful plant. If it closed its leaflets upward, after the manner of a butterfly about to settle, fair weather was shown; when the leaflets remained flat, changeable and gloomy weather was indicated; while thunder at various distances was to be foretold by the curling of the leaflets, and the nearer the thunder the greater the curl, until when the points of the leaflets crossed, the thunderstorm was indicated as being overhead. Changes of wind, hurricanes, and other phenomena were to be shown by the various curious and beautiful movements of the leaflets and stalks. These movements undoubtedly took place, but when the plant was submitted to the unprejudiced observation of Dr. F. W. Oliver and Mr. F. E. Weiss, at Kew Gardens, those gentlemen failed to find any connection between these movements and the weather, and Dr. Oliver made a report on the matter, which hits the heart of the whole subject of plant movements, by ascribing them for the most part to the agency of light and moisture. Mr. Scott, of the Meteorological Office, gave the finishing stroke to the theory by proving that the movements had no connection with either cyclones or with earthquakes, so that the sensitive plant may be considered as out of the list of weather guides, in spite of having been made the subject of an English patent.

It is a most common observation in the country that a large crop of hips, haws, and holly-berries indicates a severe winter to follow, and it is generally pointed out that nature thus provides winter food for the birds. This, too, is a fallacy.

Another weather fallacy, for which artists are responsible, is that flashes of lightning take the form of long angular lines of a zigzag shape, and of which I show you an example, taken from a work on the subject. This, when compared with the next view, which is a photograph taken direct from nature, shows that the artist had very little understood the true form of the lightning flash, which consists of numbers of short curves joining each other, something like the course of a river depicted on a map, or in some degree like the outline of a clump of leafy trees seen against the sky. But, as far as I know, there were only two artists whose acute vision saw lightning in anything like its true form. One was Turner, who long before the

time of photography, scratched his lightning flashes with a penknife, making short curved dashes across the picture; and the other was Nasmyth, the astronomer and engineer, who also saw the lightning in its true form, and duly noted the same, only to be confirmed years afterwards, when it became easy to photograph the lightning flash itself. While on the subject of lightning, I may mention that it is recorded that in one case at least a rheumatic man who had been confined to bed six weeks, received a shock from a stroke of lightning, jumped from his bed, and ran down stairs completely cured. This is related in the *Gentleman's Magazine* for June 1820.

It has been often stated that the noise of cannon will produce rain, and it is not unusual in the Austrian Tyrol to hear the church bells ringing to avert thunder. These are fallacies. The experiments in America made recently to test whether rain could be produced by exploding a large quantity of gunpowder in the air, resulted in nothing except noise and smoke, though the thing was well worth trying.

Empedocles of old is credited with the invention for chasing away the Etesian winds by placing bottles made of the skins of asses on the hills to receive them. Timæus relates this. After hearing this about Empedocles, one is not surprised to learn that he thought there were two suns, that the moon was shaped like a dish, and that the sea was the sweat of the earth burnt by the sun. All this will be found in Stanley's *Lives of the Philosophers.*

Almost in our own time, too, a "pluvifuge," or machine for blowing away rain, was proposed to be constructed in Paris. This, too, was a fallacy.

To give an account of all the various ceremonies in savage and civilised countries, which have been resorted to for the purpose of changing the course of the weather, would be here impossible; but such rites have a common origin, and a common result. They begin in error, and end in failure. In India, the rain-god is imagined to pour down showers through a sieve; in Peru there was supposed to be a celestial princess, who held a vase of rain, and when her brother struck the pitcher, men heard the shocks in thunder. In Polynesia rain comes from the angry stars, stoning the sun; while in Burmah it is still the custom to haul down rain by pulling at a rope. New Caledonia has its regular rain-making class of priests, and in Moffatt's time the rain makers of South Africa were held in even higher estimation than the kings; and on the other side of the world the Alaskan propitiates the spirit of the storm by leaving tobacco for him in a cave. In our own country, too, there have been weather witches of various grades, and one described in Drayton's *Moon Calf*:—

> "Could sell winds to any one that would
> Buy them for money, forcing them to hold
> What time she listed, tie them in a thread
> Which, ever as the seafarer undid
> They rose or scantled as his sails would drive
> To the same port whereat he would arrive."

The Finlanders at one time drove a profitable trade by the sale of winds. *After* being paid, they knitted three magical knots, and told the buyer that when he untied the first he would have a good gale; when the second, a

strong wind; and when the third, a severe tempest.[1] Sir Walter Scott also mentions that King Eric, also called "Windy Cap," could change the direction of the wind by merely turning his cap round upon his head; and old Scotch women are mentioned who, for a consideration, would bring the wind from any desired quarter.[2] The Mandan Indian rain-maker had a rattle by the noise of which he called down rain from heaven by the simple process of keeping on long enough. It is safe to say that these are all fallacies.

From the rain makers we may now turn for a moment to the almanack makers, and any one who will look up an old almanack of the early part of the last century, will find the greater part of it filled with lucubrations on the influence of the stars and constellations; he will also find a column giving for every day the parts of the body which are particularly under the celestial influences on the given dates, and when one sees for the first time this column reading—head, chest, legs, knees, feet, &c., one wonders what it can mean, but it was then so well understood, as not even to require explanation, and there was generally too a rude woodcut of a hideous human figure, tatooed with the various signs of the zodiac to show the same thing. The sort of knowledge that passed for meteorology in 1703 may be learned from the following extract from *Meteorologia* by Mr. Cock, Philomathemat. 1703,—a rare book in the possession of Mr. Symons.

"The twelve signs are divided into four sorts, for some be earthy, others watery, a third sort aery, and the fourth sort is fiery." The author then goes on to state that "Jupiter in the Skinker (whatever that may be) opposed by Saturn in the Lion did raise mighty South-west winds * * Observe when a planet is in an earthy sign he was lately dried up by perambulating a fiery sign, and after that, immediately having made his progress in an earthy sign, is quite bound up from moisture."

It seems incredible that our ancestors, only a few generations back, could have bought, paid for, and believed, such stuff as this. The early almanacks boldly gave a prediction for the weather for every day in the year; but after a time confined themselves to a general statement of the weather, for instance *Partridge's Almanack* for 1835 has the following prophesy for June. "Fertilising showers attended with thunder and lightning"—this does for the first 10 days. "Fair and at times hot" for the middle of the month, and "refreshing rain for the grass and corn" for any time between the 21st and the end of the month.

Authors of weather almanacks had already begun to seek safety in vagueness. Some of these almanacks rose to a great popularity on the strength of one lucky guess; and I think it is told of this same Partridge's almanack or some other of the class, that it owed its reputation to a curious prophesy of extraordinary weather for July 31st, when hail, rain, snow, thunder, &c. were freely indicated. Forgetting that the month had 31 days the almanack maker had omitted to insert the weather prediction for the last

[1] Olaus Magnus, *Hist. of the Goths*, 1638.
[2] Notes to *The Pirate*.

day, and a boy was sent from the printing office to know how the space was to be filled up. The weather prophet was too busy to attend to him, but at last in a passion, said: "put down hail, rain, snow, thunder, anything;" and the boy taking it literally told the compositor who duly set into type the extraordinary prediction, and which by a freak of nature came true, and made the fame and fortune of the almanack maker. This story if not true is at least "*ben trovato*," and shows the force of the bard's statement

> "Our indiscretion sometimes serves us well
> When our deep plots do pall."

The *British Almanack* for 1831, published by the Useful Knowledge Society, had no weather predictions.

Patrick Murphy published a popular weather almanack, and his fame is said to have commenced by a lucky hit in one of the earlier issues by which he indicated which would be the coldest day of the year. There is a copy of this almanack for 1838, in the library of the Society, and some former owner has evidently taken the trouble to pencil in the actual weather opposite to that predicted. There were according to this annotation 89 incorrect forecasts, 91 doubtful, and the rest correct.

This Patrick Murphy was not a mere charlatan. He had a system, and though he differed from Sir Isaac Newton and the Royal Astronomical Society, he gave much study and research to the subject of meteorology—as shown by his various books. There was an Astro-Meteorological Society as late as 1861, and we have some numbers of its *Records* in our library.

Next comes the subject of weather prophets as distinguished from mere almanack makers; and who profess, sometimes for pelf, at other times for honour and glory, to predict the weather for any future date. These are always arising, and they do not lack a certain number of followers, who, possessing a large angle of credence, duly trumpet forth the successes of their chiefs, when they are so fortunate as to make any. The stock-in-trade of a prophet is of a slender and cheap description. He must have an inventive mind, a store of self-confidence, an insensibility to ridicule, and, above all, a keen memory for his successes, and a prompt forgetfulness of his failures. He should by choice have a theory, and this should be of the elastic order, so that if a predicted event does not punctually occur, he will be ready with a sort of codicil to amend it. Hence we find that the firing of guns has been cited as a sufficient reason for falsifying a weather prediction; and railways too are said to have an adverse influence, one author (not a prophet) telling us that they may be considered as "large winnowing machines, perpetually fanning and agitating the air with prodigious power, ploughing the air as it were and causing waves of vast extent, which, invisibly enlarging like the waves of the ocean, probably meet each other, clash, and produce modified effects, as resultants from adverse motions."

One of the first weather prophets mentioned in that delightful old book, Stanley's *Lives of the Philosophers*, was Democritus, the Milesian, known as the "laughing philosopher," who foresaw a dearth of olives, and by buying

up all he could get might have made a fortune, but gave it back to the bargainers with the remark, "you can see now that a philosopher can get rich when he pleases." Then there was Pherecydes, of whom Pythagoras was a favourite pupil, who predicted an earthquake three days in advance by the taste of the water from a certain well. Perhaps the earliest of all was Elijah, who from the top of Carmel pointed out the coming squall cloud, and predicted a great rain. He forms a good model for imitation to the modern weather prophets, for he did not prophecy until he saw the storm coming, and he made no secret of his method. We have still amongst us in our country, mostly without honour, seers who supply us with weather predictions in various forms, from the modest duodecimo almanack to the flaring broadsheet which compels attention; but it would be a task too long to enter on a systematic refutation of their contradictory guesses at the weather. The last of these broadsheets that caught my eye had for the days of the gale, which Mr. C. Harding has described to us, the tame announcement of "generally overcast." This did not err on the side of boldness when considered with reference to one of the severest gales of the century.

A Spanish peasant whom I heard of in Andalucia, and who had the reputation of a weather prophet, wisely said, if you want to know the weather for to-morrow, ask me early in the morning. The Indian weather prophets who made a failure had to be silent altogether for the rest of their lives; and this causes us to regret that some of our own seers were not born in that distant land.

As to the so-called weather forecasts, they only come under the title of this paper when they fail, and as 8 out of 10 are said to be correct, I shall only say that they are honest attempts on the part of civilised governments to warn their people as far as possible against the march of known disturbances. I could wish that the term "weather indications" or "indicated weather" had been adopted, so as to make this plain to all, and that oftener, when the signs were vague, we had the simple announcement of no change indicated.

The director of this system so well known to us, and who is playfully called the "Clerk of the Weather," sometimes receives valuable hints, even from children; and I must quote one such communication.

"Please, Mr. Clerk of the Weather, tell the rain, snow and hail to stop for the afternoon, and rain in the night."

I may conclude this section by saying that it is a great fallacy to suppose that there is such a thing as a weather prophet. All the great authorities agree that in the present state of our knowledge no human being can correctly predict the weather, even for a week to come.

And now we must consider a class of weather fallacies of which the victims can only excite in a well regulated mind feelings of sadness and compassion, rather than the ridicule to which at first sight they seem more naturally entitled. I mean those weather prophets in whom the delicate mechanism of the mind is touched by disorder or decay, even if it has not

already fallen under the stroke of complete dementia, and who believe that they can not only foresee the weather, but, by an effort of their own minds, control the elements and compel the clouds.

These patients I had hoped only existed in small numbers; but, on perusing the correspondence of a prominent meteorologist, kindly lent me for the purpose, I find that there are many of this class whose name, like that of the ancient wanderer among the tombs, is "Legion," and who still come on, each prepared to drive the chariot of the sun, or by an exertion of his own will, odylize (the word I suppose will come) all the powers of nature.

Hear what Dr. Johnson's Astronomer says in *Rasselas*:—"Hear me, therefore, with attention. I have diligently considered the position of the earth and sun, and formed innumerable schemes, in which I changed their situations. I have sometimes turned aside the axis of the earth, and sometimes varied the ecliptic of the sun, but I have found it impossible to make a disposition by which the world may be advantaged. What one region gains another loses. Never rob other countries of rain to pour it on thine own."

This type of patient, as well as those who would use their supposed power for the purpose of creating fine weather during the holidays of the people, belong to the more noble sort, but there have been others, like the notorious Friar Bungay, who for sordid reasons have professed to exert a similar power. The only wonder is that anybody ever believed them.

Now, as this malady of the mind is not incurable, I will venture to offer a practical suggestion, and would recommend these patients who have nursed themselves into the belief that they possess the keys of the weather, to seek the hill top on a summer afternoon—the air and exercise will do them good —and watch the fine fleeces of cumulus cloud as they sail majestically across the sky, each with its attendant shadow below. Let the patient concentrate his attention upon one single feathery cloud, and try by the exertion of his utmost force of will to make it pause for a moment in its career; and, if he fails—"as fail full well he may"—then let him banish from his mind for ever the idea that he can by his own will dominate the whole firmament. And if he has ever gone into print upon the subject, let him go home and, like Prospero, his prototype, say:—

> "Deeper than ever plummet sounded,
> I'll drown my book,"

and so save the world from the trouble of investigating much pure nonsense. To these sufferers I can only repeat the words of one of our own kings to the last man he touched for the evil—"I wish you better health and more sense."

I must be forgiven for having only made a selection from the vast catalogue of fallacies which have accumulated about the subject, and I must continue to regret that there are still people who are ready to believe that the saints' days rule the weather, that the sun puts out the fire, that warm

water freezes sooner than cold, or that a man is a prophet because he says so himself.

This Society is clearing the ground of many weeds, and already the fallacy of the "equinoctial" gales has been exploded (by Mr. Scott), while the churchyard ghost of the supposed fatal "green Christmas" has been most effectually laid by a recent statistical paper by Mr. Dines.

Some one may ask, after all this clearing away of fallacies—What have we left? and I would venture to refer him to all the patient work which is being done in various countries, and by which a real Science of Meteorology is being slowly built up, while to the outdoor weather student I would offer this consoling reflection—There is still the sky.

REPORT OF THE COUNCIL

FOR THE YEAR 1894.

In presenting their Report, the Council have to congratulate the Society on its steady progress during the past year. There is a slight increase in the number of Fellows elected, over the number elected in 1893, and the balance at the bank, at the end of the year, is larger than the balance then brought forward.

Committees.—The Council have been materially assisted by several Committees, which have been constituted as follows:—

Editing Committee.—The President, Rear-Admiral Maclear, and Mr. Scott.

Exhibition Committee.—The President, Secretaries, Foreign Secretary, Messrs. T. W. Baker, Ellis, and Capt. Wilson-Barker.

Fog Committee.—The President, Secretaries, Foreign Secretary, Messrs. Ellis, Russell, and Williams.

General Purposes Committee.—The President, Secretaries, Foreign Secretary, Treasurer, Messrs. Ellis, Latham, and Williams.

Wind Force Committee.—The President, Secretaries, Foreign Secretary, Messrs. Chatterton, Curtis, Dines, C. Harding, and Munro.

House Accommodation Committee.—The President, Secretaries, Foreign Secretary, and Dr. Williams.

Exhibition.—The Exhibition of the year was both interesting and instructive. It illustrated "Clouds: their Representation and Measurement," and was held, as usual, in the rooms of the Institution of Civil Engineers, and was open from April 10-20. There were 135 exhibits, classified as follows:—

(1) Instruments for ascertaining the direction of motion, and the height of clouds.

(2) Thermometers.
(3) Hygrometers, evaporators, &c.
(4) Marine instruments.
(5) Anemometers.
(6) Travellers' instruments.
(7) Barometers.
(8) Sketches and photographs of clouds.
(9) Sketches and photographs of meteorological phenomena.
(10) Photographs and diagrams of instruments.
(11) Lantern slides and transparencies.

The exhibit by Mr. W. Dillworth Howard attracted general attention. It consisted of a portrait of, and two original drawings of clouds by, his grandfather, the celebrated Luke Howard, F.R.S., the author of the *Modifications of Clouds*, 1803. Through the kindness of Mr. Dillworth Howard, a copy of the portrait appears as a frontispiece to the July number of the *Quarterly Journal.*

Lectures.—A suggestion having been made that a course of lectures on "Meteorology in Relation to Hygiene" would be much appreciated by Medical Officers of Health and others, the Council approached the Sanitary Institute on the subject, the result being that a course of six lectures was given under the joint supervision of the Society and the Institute, between April 23rd and May 10th, at the Parkes Museum, as follows:—

(1) April 23rd, by G. J. Symons, F.R.S., on "Instruments and Observations and their Representation."

(2) April 26th, by H. R. Mill, D.Sc., F.R.S.E., on "Temperature of Air, Soil, and Water."

(3) April 30th, by R. H. Scott, M.A., F.R.S., on "Barometric Conditions and Air Movements."

(4) May 3rd, by W. Marriott, F.R.Met.Soc., on "Moisture, its Determination and Measurement."

(5) May 7th, by C. Theodore Williams, M.A., M.D., F.R.C.P., on "Climate in Relation to Health, and the Geographical Distribution of Disease."

(6) May 10th, by F. Gaster, F.R.Met.Soc., on "Fog, Clouds, and Sunshine."

These lectures were printed by the Sanitary Institute in their *Journal*, and through the kindness of a member of our Council extra copies of the part containing the lectures were obtained from the Institute in sufficient numbers to ensure the distribution of one copy to each Fellow.

Stations.—Observations have been accepted from the following new Stations:—Penzance, Cornwall; and Haverfordwest, Pembrokeshire. The observations have been discontinued at Lynsted, Newton Reigny, and Carmarthen. Copies of detailed monthly returns, and annual summaries of results have been supplied as usual to the Meteorological Office.

Inspection of Stations.—All the Stations south of lat. 52° N. and east of long. 2° W., and such new stations as could be conveniently visited, have

been inspected, and been found to be, on the whole, in a satisfactory condition. Mr. Marriott, in his Report (which will be found in Appendix I., p. 65), states that he has called the special attention of the observers to the necessity of carefully adjusting the Campbell-Stokes sunshine recorder.

Research Fund.—This fund has been augmented by a donation of £10 from Mr. W. M. Beaufort, and also by the sum of £2 1s. 6d. interest received.

Donations.—Considerable additions have been made to the Library during the year, of which a list will be found in Appendix V., p. 81. Several photographs and lantern slides have been received from different donors.

Quarterly Journal.—This publication has contained several papers of considerable interest, more particularly those dealing with storms and wind force measurement.

Meteorological Record.—This publication has been brought up to June, 1894, and is now in the fourteenth year of its existence.

Phenological Report.—This interesting and instructive annual Report was, as usual, prepared and was read by Mr. Mawley at the February meeting, and it is satisfactory to find that the number of observers has been well maintained.

Offices.—Early in the year the Council were informed that the remaining room on the second floor of 22 Great George Street, would be vacant at Michaelmas. A Committee was appointed to consider the desirability of increasing the accommodation, and on receiving their report the Council, having regard to the growing needs of the Library, took the room on a lease similar to, and running concurrently with, the old lease. The room has now been furnished, and is a great acquisition to the Society.

Hour of Meeting.—The change of the hour of the evening meetings from 7 p.m. to 8 p.m. has not proved conducive to a large attendance, owing to the late hour to which the business extended, and the Council in view of this fact, and of numerous representations made to them, decided to alter the time of commencement to 7.30 p.m. during the coming Session, and to close every meeting not later than 9.30 p.m. The Council hope that this arrangement will be found more convenient.

Fellows.—The changes in the number of Fellows are exhibited in the following table, which shows an increase of six during the year.

Fellows.	Annual.	Life.	Honorary.	Total.
1893, December 31st...	406	135	17	558
Since elected	+39	+4	+2	+45
Deceased..................	−10	−1	−2	−13
Retired....................	−24	...	...	−24
Lapsed.....................	− 1	...	...	− 1
Defaulter	− 1	...	...	− 1
1894, December 31st...	409	138	17	564

Deaths.—The Council have to announce with much regret the deaths of eleven Fellows, and of two Honorary Members. The names are :—

Edwin Clark, M.Inst.C.E., F.R.A.S.	elected Mar. 19, 1862.
Padre Francisco Denza (Honorary Member)	„ June 15, 1870.
Wilhelm A. von Freeden (Honorary Member)	„ June 17, 1874.
George Garnett, M.Inst.C.E.	„ May 17, 1876.
John Hill, M.Inst.C.E.	„ Nov. 16, 1881.
Robert Lawson, LL.D., F.S.S.	„ Apr. 18, 1888.
John Lovel	„ Mar. 18, 1891.
Henry Bean Mackeson, F.G.S.	„ Nov. 16, 1881.
Capt. John Shortt, R.N. [died in 1893]	„ Dec. 18, 1889.
William Topley, F.R.S., F.G.S., Assoc.Inst.C.E.	„ June 15, 1892.
Rev. John Turner Wilkinson, M.A., LL.D.	„ Dec. 19, 1888.
Henry Woolcock, Assoc.M.Inst.C.E. [died in 1892]	„ Dec. 17, 1890.
Henry Yool	„ Nov. 20, 1878.

APPENDIX I.

Inspection of Stations, 1894.

ALL the stations in the south-eastern part of England (that is south of 52° N. lat., and east of 2° W. long.), as well as three new stations in the south-west, have been visited during the year, and were found to be generally in a satisfactory condition.

The observers appear to take an intelligent interest in the work, and to be anxious to supply trustworthy data from their stations.

The number of thermometers tested has been 141. Changes of zero have taken place in 12 thermometers; 8 mercurial having risen and 4 spirit having gone down since the last examination. In a few cases the thermometer tubes had shifted somewhat, so that the divisions on the tube did not coincide with those on the scale. These I adjusted where possible.

Some of the maximum and minimum thermometers had back plates with ring only. In such cases I either put on fresh back plates having a hole and slot, or subsequently forwarded them to the observer for him to put on.

At one station the maximum thermometer was out of order, and had been so for several weeks. This is the first instrument of the Negretti and Zambra pattern which I have found to fail, and act as an ordinary thermometer, after 2 or 3 years' service.

Most sunshine recorders of the Campbell-Stokes pattern were somewhat out of adjustment, the glass ball not being in the centre of the frame. This is readily tested by passing a sovereign round between the ball and the card. If the sovereign passes round uniformly, the ball is in the centre of the frame; but if it sticks at any point the instrument requires readjustment. This is done by moving the pedestal until it is quite in the centre of the frame.

In what is called the "universal sunshine recorder" the ball is kept in position by being clamped axially. Unless this be very carefully adjusted and attended to, the ball will slide down a little and put the instrument out of focus; furthermore, the edge of the frame will also cut off the early and late rays of the sun. Consequently some of the record will be lost.

I would recommend all observers who have a burning recorder to occasionally test this adjustment by simply passing a sovereign round between the ball and the card.

WILLIAM MARRIOTT.

October 13th, 1894.

NOTES ON THE STATIONS.

ADDINGTON HILL, *September 13th.*—The observations appeared to be correctly taken, and the instruments to be kept in good order. The maximum thermometer (Negretti and Zambra's pattern) had for a few weeks been acting as an ordinary thermometer. As the constriction had evidently become ineffective, I recommended that the thermometer be sent forthwith to the makers for repair. I put on fresh back plates to the minimum thermometer. The screen required painting.

ADDISCOMBE, *September 13th.*—Miss Mawley had removed from Lucknow House, but the instruments still remained in the garden, the observations being taken by the gardener. It is probable that the station will be discontinued at the end of the year. There was no change in the instruments.

ASPLEY GUISE, *September 11th.*—This station was in good order, but as Mr. Dymond was away from home I did not test the thermometers. The ball of the sunshine recorder was not quite in the centre of the frame.

BEDDINGTON, *September 13th.*—This station was in good order. The tubes of the thermometers required fixing and adjusting.

BENNINGTON, *September 21st.*—This station was in good order. On comparing the thermometers it was found that the grass minimum had gone down $0^{\circ}\cdot5$.

BERKHAMSTED, *September 11th.*—This station and all the instruments were in good order. The ball of the sunshine recorder was not in the centre of the frame.

BEXHILL-ON-SEA, *September 5th.*—I found that Mr. C. Wiggins had charge of Mr. Tenison's instruments, but that he was not observing with them, nor could he undertake to supply records. He promised, however, to forward the sunshine values from the Jordan recorder, which is still continued at the Coast Guard station.

BOURNEMOUTH, *August 21st.*—I inspected and examined the instruments at the stations both at the Cemetery and the Coast Guard. The Corporation have not, however, yet decided that the results of the observations may be published by the Society.

BRIGHTON, *September 4th.*—There was no change in the thermometers. The grass minimum had some spirit separated. The screen required

painting. As it is possible that the spray from the fountain may sometimes reach the rain gauge, I recommended that the display of water should be regulated in windy weather, or the rain gauge moved. The ball of the sunshine recorder was not quite in the centre of the frame. This I adjusted. The upper part of the frame for the small (winter) cards is taken off in the summer to prevent the ends cutting off the sun's rays.

Chelmsford, *August 31st.*—There was no change in the thermometers. The minimum had a little spirit at the top of the tube which I shook down. The screen required painting and also to be made firmer.

Cranleigh, *July 20th.*—This station is at the Surrey County School; and the instruments are in a railed off enclosure in a field on ground sloping to the south. I recommended that the position of the maximum be altered in the screen. The grass minimum had some spirit at the top of the tube.

Ditchling, *September 4th.*—The instruments are placed on a small lawn, and are surrounded by wire netting about 6 feet high. I recommended that this should be reduced to about 3 feet only. Ditchling Beacon is nearly two miles to the south, and rises to a height of 750 feet.

Eastbourne, *September 5th.*—On comparing the thermometers I found that the minimum read 0°·2 too low. The index of the grass minimum did not move freely down the tube; there was also a speck or two of dirt. Evidently the tube was imperfect, and this accounted for the index sometimes getting out of the spirit. The screws for the maximum and minimum required tightening to prevent vibration. Scarlet runners had been allowed to grow somewhat near the rain gauge. The sunshine recorder is on the tower of the Grand Hotel. The ball was not quite in the centre of the frame.

Folkestone, *September 7th.*—This station is at the Sanatorium on the East Cliff. The instruments are in a small railed off enclosure, the observations being taken by the matron. The thermometers required rearranging in the screen. The sunshine recorder (Jordan twin-instrument) is on the roof of one of the buildings. The hills probably intercept a little of the early and late sunshine.

Guernsey, *August 18th.*—As the trees have grown somewhat considerably of late years, I recommended that the rain gauge be moved to the large lawn, where there will be a good exposure. The tube of the minimum was loose and had slipped down. This I re-adjusted. The screen required painting. The sunshine recorder appeared to be 15 minutes slow. The late evening sun is just cut off by the roof.

Halstead, *August 31st.*—The instruments were in good order. The minimum appeared to have gone up 0°·3.

Harestock, *August 22nd.*—The station and instruments were in good order. The ball of the sunshine recorder was not quite in the centre of the frame. Colonel Knight has had a hole made for taking observations with a 70 feet earth thermometer.

Liss, *August 25th.*—This station, which is on the crest of the hill, has a good exposure. The sunshine recorder (universal pattern) was not working correctly, as it was not set for the proper latitude. I levelled the instrument

and set it to the proper latitude, but could not adjust it for time as the sun was not then shining.

MARGATE, *July 13th.*—This station was in good order. The minimum had gone down 0°·5. The sunshine recorder (universal pattern) is mounted on a brick pier on the roof of the house. The ball had slipped down somewhat and was not in the centre of the frame, and consequently the edges of the frame cut off some of the early and late sunshine.

MARLBOROUGH, *July 11th.*—There was no change in the thermometers. Bean sticks had been put in close to the rain gauge. These I requested should be removed. The trace of the sunshine recorder was not parallel with the card. This was owing to the frame not being properly fixed with the ball in the centre.

NEWQUAY, *July 24th.*—The thermometer screen is placed in a field not far from the cliff, in a very open situation. The rain gauge is placed in a kitchen garden on the south side of the main road. The sunshine recorder is mounted on the ridge of a stable, and is well exposed. The ball was not quite in the centre of the frame.

OLD STREET, LONDON, *August 29th.*—In the early part of the year the minimum for some time read about 3° too high. Another minimum, which was used in its place, also read 3° or 4° too high. It was discovered afterwards that a bubble had been generated in the tube near the bulb. I recommended that the tree near the rain gauge should be cut back.

PENZANCE, *July 25th*—The instruments are in the Morrab Gardens, on a level lawn in front of the Library. I recommended that the screen and rain gauge be shifted, so as to be out of the influence of the sloping bank. The thermometers required rearranging in the screen, and new back plates to be put on the maximum and minimum. The observer was instructed to read the thermometers to tenths of a degree. The two sunshine recorders (burning and photographic) are mounted on a platform on the south side of the dome of the market hall; the exposure is very good. The early and late sun's rays were not recorded by the burning instrument, as the ball had slipped down and was consequently not in the centre of the frame. This I readjusted.

PORTSMOUTH, *August 23rd.*—On comparing the thermometers it was found that the dry and wet had gone up 0°·1. I recommended that the thermometers should be read to tenths of a degree. The sunshine recorder was mounted on top of the screen and did not get the evening sun. I suggested a more suitable exposure for the instrument, and also recommended that the traces be fixed before being measured. As an additional building will shortly be erected, it is probable that the rain gauge may have to be moved to the north kitchen garden.

PRINCETOWN, *July 26th.*—The instruments were in good order, the stand having recently been painted and the outside cylinder of the rain gauge soldered. I brought away with me the spare set of thermometers.

REGENT'S PARK, *August 29th.*—There was no change in the thermometers. The screen required cleaning and painting inside. The

sunshine recorder is mounted on a wooden tower. Owing to the shrinkage of the wood the recorder was somewhat out of level.

Sheerness-on-Sea, *September 20th.*—There was no change in the zeros of the thermometers, but the grass minimum had 3°·6 of spirit at the top of the tube. The position of the maximum and minimum in the screen required altering. I recommended that the screen be painted and that the trees be cut back as much as possible.

Strathfield Turgiss, *July 10th.*—This station was in good order. The thermometers are mounted in the old Kew screen. On comparing the thermometers it was found that the dry bulb had gone up 0°·1.

Swarraton, *August 22nd.*—There was no change in the thermometers. The muslin on the wet bulb required renewing.

Tavistock, *July 26th.*—The thermometers were in the kitchen garden on ground sloping rapidly from north to south. I recommended that they be removed to the terraced lawn at a lower elevation, on which the rain gauge is also placed. If this were done Mr. Glyde would have no difficulty in taking evening observations.

Tenterden, *September 6th.*—The sunshine recorder is placed in a garden on the east side of the road, and removed at 9 a.m. to a post at the end of Mr. Mace's garden on the west side of the road. By this means all the available sunshine is recorded.

Tunbridge Wells, *September 17th.*—On comparing the thermometers it was found that the minimum had gone down 0°·4. The screen required painting. Mr. Smart had had the frame of the burning recorder (universal pattern) cut in two places with the view of letting down the eastern flap in the morning and the western flap in the afternoon, as he believed the edges of the frame cut off the sun's rays. The ball, however, was not in the centre of the frame.

Ventnor, *August 24th.*—On comparing the thermometers it was found that the minimum had gone down 0°·2. I had the rain gauge attended to by the engineer, as the funnel fitted tightly and the outer cylinder had been dented by croquet balls.

Wallington, *September 13th.*—The instruments were removed in June to Malden road, about 150 yards from their former position in Manor road. The exposure is good. The sunshine recorder is placed on the roof of the house.

Weymouth, *August 20th.*—The station was in good order. The minimum had about 0°·2 of spirit at the top of the tube. Mr. Eyles had just got a burning sunshine recorder, which he had mounted on a tripod on the top of the house at the end of the pier. The ball was not quite in the centre of the frame.

Worthing, *September 3rd.*—There was no change in the zeros of the thermometers. As the end of the tube of the maximum was broken off and the tube loose, I readjusted it and made it secure.

APPEN-

STATEMENT OF RECEIPTS AND EXPENDITURE

Receipts.

	£ s. d.	£ s. d.
Balance from 1893		168 10 4
Subscriptions for 1894	666 1 0	
Do. former years	51 0 0	
Do. paid in advance	43 2 0	
Life Compositions	84 0 0	
Entrance Fees	36 0 0	
		880 3 0
Meteorological Office—Copies of Returns	112 12 10	
Do. Grant towards Inspection Expenses	25 0 0	
		137 12 10
Dividends on Stock (including £40 11s. 4d. from the New Premises Fund)		113 12 9
Sale of Publications		30 7 10
		£1330 6 9

DIX II.

FOR THE YEAR ENDING DECEMBER 31ST, 1894.

EXPENDITURE.

	£ s. d.	£ s. d.
Journal, &c.:—		
Printing Nos. 89 to 92	130 6 3	
Illustrations	28 17 11	
Authors' Copies	15 16 6	
Meteorological Record, Nos. 51 to 54	48 1 0	
Registrar-General's Reports	8 8 0	
		231 9 8
Printing, &c.:—		
General Printing	19 3 0	
Stationery	18 2 9	
Forms	6 2 0	
List of Fellows	9 12 6	
Books and Bookbinding	15 17 0	
		68 17 3
Office Expenses:—		
Salaries	413 10 0	
Rent and Housekeeper	156 5 6	
Furnishing new room, Repairs, Coals, &c.	53 15 5	
Postage	58 10 1	
Petty Expenses	15 7 6	
Refreshments at Meetings	14 7 8	
Exhibition Expenses	8 5 11	
Lecture Expenses	19 1 5	
		739 3 6
Observations:—		
Inspection of Stations	43 18 11	
Observers	9 2 0	
Instruments	1 4 0	
		54 4 11
Stock:—		
Purchase of £41 5s. 7d. 2½ per cent. Annuities		42 0 0
		1135 15 4
Balance:—		
At Bank of England	184 18 4	
In hands of the Assistant-Secretary	9 13 1	
		194 11 5
		£1330 6 9

Examined and compared with the Vouchers, and found correct,

R. H. CURTIS, } *Auditors.*
FREDC. GASTER, }

January 10*th*, 1895.

APPEN-

ASSETS AND LIABILITIES

LIABILITIES.

	£	s.	d.
To Subscriptions paid in advance	43	2	0
,, Excess[1] of Assets over Liabilities	2983	1	6
	£3026	3	6

[1] This excess is exclusive of the value of the Library and Stock of Publications.

Examined,
R. H. CURTIS,
FREDC. GASTER, } *Auditors.*

WILLIAM MARRIOTT, *Assistant Secretary.*
January 10*th*, 1895.

NEW PREMISES FUND,

	£	s.	d.
Amount paid to the Society's Funds towards the increased rent of the New Premises	40	11	4
	£40	11	4

Examined,
R. H. CURTIS,
FREDC. GASTER, } *Auditors.*

WILLIAM MARRIOTT, *Assistant Secretary.*
January 10*th*, 1895.

RESEARCH FUND,

	£	s.	d.
Amount invested in purchase of £101 0s. 3d. 2¾ per cent. Consols at 99	100	0	0
Do. Do. £11 14s. 2d. at 103½	12	1	6
	£112	1	6

Examined,
R. H. CURTIS,
FREDC. GASTER, } *Auditors.*

WILLIAM MARRIOTT, *Assistant-Secretary.*
January 10*th*, 1895.

DIX II.—Continued.

ON JANUARY 1ST, 1895.

ASSETS.

	£ s. d.	£ s. d.
By Investment in M. S. and L. R. 4½ per cent. Debenture Stock, £800 at 152	1216 0 0	
,, ,, in N. S. W. 4 per cent. Inscribed Stock, £654 18s. at 108½	710 11 8	
,, ,, in L. & N. W. R. Ordinary Stock, £200 at 177	354 0 0	
,, ,, in 2¾ per cent. Annuities, £141 5s. 7d. at 101¾	143 15 0	
		2424 6 8
,, Subscriptions unpaid, estimated at	50 0 0	
,, Entrance Fees unpaid	16 0 0	
,, Interest due on Stock	30 13 9	
		96 13 9
,, Furniture, Fittings, &c.	215 12 1	
,, Instruments	94 19 7	
		310 11 8
,, Cash at Bank of England	184 18 4	
,, Cash in hands of Assistant-Secretary	9 13 1	
		194 11 5
		£3026 3 6

DECEMBER 31ST, 1894.

	£ s. d.
Interest received on investment	40 11 4
	£40 11 4

NOTE.—The Society holds on account of this Fund £1199 0s. 2d. South Australian 3½ per cent. Inscribed Stock.

DECEMBER 31ST, 1894.

	£ s. d.
Contribution by Dr. C. T. Williams	100 0 0
Do. ,, Mr. W. M. Beaufort	10 0 0
Interest received on investment	2 1 6
	£112 1 6

NOTE.—The Society holds on account of this Fund £112 14s. 5d. 2¾ per cent. Consols.

APPENDIX III.

OBITUARY NOTICES.

Edwin Clark was born at Marlow on January 7th, 1814, and was the eldest of three boys. (His brother, Latimer Clark, F.R.S., is well known in the scientific world.) After boarding at an old school in the town, he was at the age of eleven sent to a French school in Normandy, where in three years he acquired such a thorough knowledge of French that his translation of the *Chronicles of the Canongate* into French was published in France. He returned home in 1828, and was placed in a solicitor's office; but scientific tastes seriously interfered with his application to this work. Such tastes were but little understood at the time, and the boy was regarded by all his friends as a ne'er-do-well. But his diligence and attention to science, especially in its practical aspects, ultimately bore fruit. He obtained a position as teacher in his old school, and one of his colleagues, who was reading for the University, strongly urged the advantage he would derive could he go up for honours at Cambridge. A small legacy which his mother received at this time was devoted to this purpose. But at the end of two and a half years his parents found it impossible to continue his maintenance at the University. After some engagements as schoolmaster, Mr. Clark resolved on an apparently reckless project. He had long wished to see something of the world, and with £10 in his pocket and a knapsack on his back he started on a wild and indefinite tour on the Continent. He visited the Rhine, Switzerland, and crossed the Alps into Italy, making observations on glaciers and meteorology, and various scientific collections. He became an artist, and continued his tour through Rome to Naples, Pompeii, Salerno, Pœstum, and at length returned to his home at Marlow in 1839, to the great delight of his parents. He at once accepted a mathematical mastership at Coombe Wood, and then at Brook Green, Hammersmith, and collected a small library and a stock of scientific apparatus.

But this profession did not hold him long. In 1845 the railway mania had resulted in the great financial crisis which threw so many surveyors and engineers out of employment, and at this inopportune juncture he suddenly abandoned the school to assist in the survey of the proposed line between Brighton and Oxford. This project speedily collapsed, but Clark's determination to be an engineer was taken. With an introduction of the most slender character, he repaired to Mr. R. Stephenson's chambers in Great George Street, an office that was destined afterwards to become his own for so many years. Mr. Stephenson was at that time overwhelmed with work, especially in the great contest between the broad and narrow gauge, and Mr. Clark was at once informed of the hopeless improbability of a personal interview. But, nothing daunted, he waited patiently for hours every day in the ante-room during a period of three weeks, and at last was rewarded by a chance interview. He was fortunate enough to be able to prove his

abilities almost immediately, and the foundation of his career as an engineer was laid.

The problem on which he won his spurs was that of the Britannia and Conway Tubular Bridges, for the construction of which he was ultimately placed in absolute control as resident engineer. He was for many years chief engineer to the Electric Telegraph Company, and invented and patented the hydraulic graving dock and canal lift. He constructed the great dock at Bombay, and others at Malta and London. He was the designer of a host of bridges, including the great swing bridges at Arnheim, Lyons, and Rochester, the Aire Tubular Bridge, and the Scarborough Viaduct. He was the original inventor of the block system of signalling. Mr. Clark also laid the cable from Dungeness to Holland, and negotiated the agreements and erected the telegraph for the chief English railways. He was engineer to the Crystal Palace Company, and completed the building of the Palace after the fire.

Mr. Clark retired from business in 1876, and after travelling for two years in South America, he settled down at Great Marlow, where he devoted himself to astronomical and meteorological observations. He died from cancer on October 22nd, 1894.

He was elected a Fellow of this Society on March 19th, 1862.

Francisco Denza.—The following notice is abridged from the *cenni necrologici* of Padre Denza:—

By the death of Father Francisco M. Denza, which occurred on December 14th, 1894, not only has this our college of S. Carlo a' Catinari, to which he belonged since 1890, and that of Moncalieri, to which he had been attached for a number of years, sustained a very great and sad loss, but the whole of our congregation is equally affected by it. Father Denza was in Italy one of the most assiduous cultivators of natural science, and in meteorology, to which he devoted himself with the greatest diligence, no one could contest the victory with him. The "Specola Vaticana," reclaimed to new life by the munificent wisdom of Leo XIII., loses in him more than a Director and Father, who by the authority of his name and his constant activity, had raised it to be one amongst the first observatories of Europe. But above all, we can testify that he was a man who united in himself all the rigidness of the most modern culture with the sincerity of an ancient faith, and to his scientific labours the assiduous study of religious perfection. Our order possessed in him not only an illustrious member, as he is now denominated, but an obedient son and an indefatigable worker. Born at Naples, of Michele and Virginia Zigzi, June 7th, 1834, at the age of 17 he requested to be clothed with our habit (of a Barnabite), which he accordingly was invested with in 1850. He first studied in our College of S. Filippo, in Macerata, and then was sent to Rome, where, under the celebrated Padre Secchi, he devoted himself to mathematics and physics until 1857, when he was sent to the university of Turin. He then founded an observatory which became the central one of the Italian Meteorological Society, well known in

the world of science. He continued his lectures in this university, and had pupils from every part of Italy until 1886, when he had a paralytic stroke; but he recovered sufficiently from it to be able to fill the office of Vice-Rector, and to help many by his ability and long experience. As he grew in years his fame grew also.

He published many pamphlets on science and on observations on eclipses, on the Aurora Borealis, on the falling stars, and on the variations of the magnetic needle, &c. One popular treatise on Astronomy is his "*Armonie dei Cieli*," published repeatedly, and he translated into Italian Mr. Scott's *Elementary Meteorology*.

If in the present day upwards of 200 observatories are spread over our country, which in that respect is inferior to few others, it is due to the powerful influence of our dear Father. Thus the "*Corrispondenza Meteorologica Italiana Alpino-Apennina*," founded by him in 1859, and "*La Societa Meteorologica Italiana*," constituted in 1882 under the Hon. Presidency of H. M. King Umberto I., under the effectual direction of our Father Denza, have become two national institutions.

He also attended many congresses held for the diffusion of science. In 1878 we find him at the International Congress of Meteorology in Paris, in 1879 at Rome. In 1881 we find him in the month of April at Algiers for a Scientific Congress, in September at Milan for the Subalpine Congress, and in October at Venice for the General Geographical Congress. In 1884 he represented the Holy Father at the Congress of the Scientific Association of France at Rouen, and took advantage of this journey to France to visit Holland and England. In December 1887, although still suffering from a second attack of apoplexy, he went to Rome to be present at the jubilee of Leo XIII., and remained until February 1888 in order to co-operate in the Scientific Exposition of the Clergy, and in the following year promoted the Institution of "la Specola Vaticana," of which he was appointed Director by the Pope, and took up his residence in a modest apartment prepared for him. To that institution he devoted four years of assiduous work, spending part of the summers at the Royal College of Moncalieri.

In 1892 fresh symptoms of his former malady appeared, and being taken suddenly ill just after having had an audience of the Pope, he expired 24 hours after, having received all the comfort of the last sacraments and benediction of the Holy Father.

Such was the external glory of this beloved Father, which only was generally known; but we who were well acquainted with him can appreciate the truer and more hidden glory of his Christian virtues. The Royal College of Carlo Alberto owes to him a great portion of the fame it enjoys, not only in Piedmont, but all over Italy, and in Father Denza it has suffered a very great loss.

Meanwhile, his name will remain blessed amongst us, and may it lead many others to cultivate science with the same activity and rectitude that he did.

He was elected an Honorary Member of this Society on June 15th, 1870.

WILHELM ADOLF VON FREEDEN was born at Norden in East Friesland, May 22nd, 1822, and died at Bonn, January 11th, 1894, after a short attack of inflammation of the lungs. From 1845-56 he was Teacher of Physics in the Gymnasium at Jeven, and from 1856-67 Director of the Navigation School at Elsfleth near Bremen.

He is best known to science as the Founder and first Director of the Norddeutsche Seewarte at Hamburg, an Institute which in 1875 was reorganised as an Imperial Establishment under its present name, the Deutsche Seewarte, Dr. G. Neumayer being appointed Director. Herr von Freeden at this date withdrew to Bonn, where he spent the remainder of his life, occupying himself *inter alia* with the editing of the *Hansa*, a newspaper he had started.

He took a principal part in the founding of the North German Lloyds Company. The activity of the Seewarte under his management was most creditable, and numerous papers from his pen have appeared in the *Zeitschrift der Oest. Met. Gesellschaft*, and elsewhere.

He was for five years, 1871-6, Member of the Reichstag for Hamburg, but declined re-election on removing to Bonn.

He was elected an Honorary Member of this Society on June 17th, 1874.

JOHN HILL, M.Inst.C.E., was at the time of his death one of the oldest county officials in Ireland. He was appointed Chief Surveyor of Clare in 1845, an office which he held for about 10 years, when he went to King's County to fill a similar position. After 12 years' service there he renewed his connection with Clare in 1867, and remained County Surveyor till his retirement in 1893. He was for several years Chairman of the Town Commissioners, and also Vice-Chairman of the Clare Castle Harbour Board.

He died on January 23rd, 1894, aged 81.

He was elected a Fellow of this Society on November 16th, 1881.

INSPECTOR-GENERAL ROBERT LAWSON was born in 1815, and belonged to an Aberdeenshire family. He entered the army as an Assistant Surgeon in 1835, became Surgeon in 1845, Deputy Inspector-General in 1854, and Inspector-General of Hospitals in 1867, and retired on half-pay in 1872. He was present at the storming and destruction of the fortified Mandingo town of Sabajee on the Gambia in 1853, and served in the Crimea during 1854 and 1855. He received the Crimea medal with Sebastopol clasp, the 4th class of the Medjidieh and the Turkish medal. The degree of LL.D. was conferred upon him in 1884 by the University of Aberdeen, and he was appointed one of the Honorary Physicians to the Queen in 1891.

When serving in the West Indies and the West Coast of Africa, he showed early the scientific bent of mind that pervaded the whole of his career by observations regarding meteorology and the laws of storms—a subject which was at this time little regarded and only in its infancy. He was one of the earliest to draw attention to the rotation theory of cyclones, but his work in

this respect, like much of his later work, was ahead of his time, and did not attract the notice it deserved. He further made valuable observations concerning the spread of malarial disease and yellow fever by means of air-currents and prevailing winds, and the natural means of protection from their spread by such causes. There are now only two officers alive who ever served as Inspector-General of Hospitals, a rank which became obsolete under the Royal Warrant of March 1st, 1873.

His retirement from the army in 1872 did not entirely break his connection with the service, as he acted on several commissions, and assisted in the development of the modern system of ambulance. He was an active member of the Epidemiological and Statistical Societies, and was president of the former. In their Transactions and elsewhere a large number of publications have appeared from his pen at various times, dealing chiefly with the methods by which cholera and other epidemic diseases are spread; and he delivered the Milroy Lectures, in 1888, on Epidemic Influences, Yellow Fever, and Cholera. Perhaps the best known of his labours, at least among the general profession, were those referring to the progress of epidemics from north to south of the earth at a given rate of progress at right angles to the distribution of the isoclinal lines of the magnetic dip, which were termed the pandemic waves. Having access to the records of the Army Medical Department, he collected a great body of statistics bearing on this point showing the influence of these waves on all infectious diseases.

Whilst serving in the army he was eminently just and kind to all under him, and the advocate and true friend of those who showed any unusual industry, ability, or merit. His sense of duty was always very strong, and he never spared himself in the way of personal trouble and painstaking to discharge such duties as fell to his lot conscientiously and well.

He died at Aberdeen on February 8th, 1894, at the age of 79.

He was elected a Fellow of this Society on April 18th, 1888.

John Lovel was born at Halperthorpe, Yorkshire, on December 13th, 1862, and was early left to the care of his father, his mother dying in February 1866. He received most of his instruction from his father, who for some years kept an elementary school at Weaverthorpe. After being apprenticed for several years to a joiner and wheelwright, Mr. John Lovel in 1883 joined his father at Driffield, who three years before had purchased a part of the site he at present occupies, which he prepared for, and has since carried on, as a strawberry nursery.

Twelve years ago the father commenced rainfall observations, which so interested Mr. John Lovel that in 1890 he organised a climatological station, and became a valued observer for the Royal Meteorological Society.

After the waterspout and flood at Langtoft in July 1892, Mr. John Lovel made a study of the question of waterspouts and cloudbursts, and communicated a paper on the subject to the Royal Meteorological Society.

He also sent to the Society the results of a year's comparative observations, which he had made with two sets of maximum and minimum thermometers, read and set at 9 a.m. and 9 p.m.

Mr. John Lovel had a thorough appreciation of, and was well in touch with, every day subjects. He was a most enjoyable companion, and ever ready to impart in a quiet way some interesting fact or other relating to the great problems of nature.

He died on February 16th, 1894, aged 81 years.

He was elected a Fellow of this Society on March 18th, 1891.

William Topley, F.R.S., F.G.S., Assoc.Inst.C.E., was born at Greenwich on March 13th, 1841. He was educated in local schools, and entered the Royal School of Mines in 1858, which he left in 1862, and joined the staff of the Geological Survey of England and Wales, being initiated into the methods of field-work by Dr. Le Neve Foster, with whom he jointly brought out a remarkable paper in 1865 on the "Denudation of the Weald," proving that the formation of the Weald of Kent and Sussex, its central ridge and surrounding Downs, alike owed their origin to the long continued sculpturing of rain and rivers. Mr. Topley surveyed important areas, both amongst the Wealden and Cretaceous rocks of Kent and the Coal Measures of the North of England; of the former area he wrote a Survey Memoir of a most exhaustive character, in which he embodied the whole of the existing knowledge; the work is remarkable for a combination of scientific methods and work with a bibliographical instinct which was characteristic of the mind of the author. In 1880 Mr. Topley was recalled from field-work to take charge of the publication of maps and memoirs at the London office of the Geological Survey, a post he held till his death.

He joined the British Association in 1872, and served as Secretary and Reporter of Section C (Geology) between that year and 1888 no less than 15 times. To the Working Committees he was ever ready to give valuable aid; he joined the Circulation of Underground Waters Committee in 1883, but had previously assisted in the work, since its initiation on the suggestion of Dr. Hull in 1874, while the valuable reports of the Coast Erosion Committee were wholly drawn up by him; this Committee was suggested by Mr. De Rance in 1881, Mr. Topley from the first acted as its Secretary, and secured the assistance of the War Office, Admiralty, and other Government Departments; he had intended to present the final Report and recommendations this year. He was early placed on the Sub-Wealden Exploration Committee, and in 1872 was officially sent down by the Geological Survey to record the phenomena observable, on which he presented a valuable report. His paper on "the Geological Distribution of Gold and Silver," read at the British Association, was ordered to be printed *in extenso* by that body.

In contributions to the Royal Agricultural and other Societies, he opened up a new field of research, in the relation of parish boundaries to the geological structure, and the influence of the latter on water supply, character of the surface of the ground, and even of climate.

To the International Geological Congress in 1888 he acted as one of the secretaries, and had been previously appointed in 1881 to superintend the publication of the British Section of the International Geological Map; and he gave to the recent Royal Commission on London Water Supply long-continued and valuable assistance in the illustrations and tables accompanying their Report.

Medical science has benefited by the assistance given by him to Sir George Buchanan's researches on *The Distribution of Phthisis as affected by the Dampness of the Soil*, and by his address on "Geology in relation to Hygiene," given in 1890, when Chairman of the Geological Section of the Sanitary Institute.

He took an active part in the commencement of *The Geological Record*, and eventually became its editor in 1887, a post for which his great knowledge of bibliography well fitted him. His power of work and industry were remarkable, and it is infinitely to be regretted that his wonderful enthusiasm impelled him ever to assist all who asked him for aid, as, by the constant drain on his reserve of force, he fell a ready victim when attacked by gastritis in Algeria, against which he struggled in vain, though he reached his home at Croydon, only to die in a few days, on September 30th, 1894. Whether as an officer of the Survey, or Sectional Secretary of the British Association, or President of the Geologists' Association, or scientific worker, or in his home life relations, we find him ever willing to work, to help, and to assist those around him, and to endeavour to make life pleasant. His work in numerous most useful directions has ceased, but his kindly memory will long be remembered, and lines of investigation he has suggested be followed up, perhaps by those who hardly realise the first initiation that led to their researches.

He was elected a Fellow of this Society on June 15th, 1892.

APPENDIX IV.

BOOKS PURCHASED DURING THE YEAR 1894.

Archibald, E. D.—Clouds and Cloudscapes. (Article in *English Illustrated Magazine*, Vol. XI. 1893-4).

Beaver, P.—African Memoranda; relative to an attempt to establish a British setttlement on the Island of Bulama, on the western coast of Africa, in the year 1792. 4°. (1805).

China.—Meteorological Observations taken at Tinghae in Chusan from Aug. 1840 to Feb. 1841. 8°.

Dickson, H. N.—Meteorology. 8°. (1893).

Forster, T.—Annals of some remarkable ærial and Alpine voyages, including those of the author. 8°. (1832).

Hellmann, G.—Neudrucke von Schriften und Karten über Meteorologie und Erdmagnetismus. No. 3. Luke Howard. On the Modifications of Clouds. London 1803. Mit einer Einleitung und drei Tafeln Wolkenbilder in Facsimile. 4°. (1894).

Kupffer, A. Th.—Voyage dans l'Oural entrepis en 1828. 8°. (1833).

London, India Office.—A Memoir on the Indian Surveys. By C. R. Markham. 8°. (1871).

LONDON, ROYAL GEOGRAPHICAL SOCIETY.—Journal, Vol. 50. 1880. 8°. (1881).

M'DONALD, A.—A Narrative of some passages in the history of Eenoolooapik, a young Esquimaux, who was brought to Britain in 1839, in the ship *Neptune* of Aberdeen, on account of the discovery of Hogarth's Sound. 8°. (1841).

MUDDOCK, J. E.—Davos-Platz as an Alpine Winter Station for consumptive patients. 8°. (1881).

NARRATIVE of the dreadful disasters occasioned by the Hurricane which visited Liverpool and various parts of the Kingdom, January 6th and 7th, 1839. 12°. (1839).

OFFICIAL YEAR BOOK OF THE SCIENTIFIC AND LEARNED SOCIETIES of Great Britain and Ireland, 1894. 8°. (1894).

THEOPHRASTUS of Eresus on Winds and on Weather Signs. Translated, with an Introduction and Notes, and an Appendix on the direction, number and nomenclature of the Winds in classical and later times, by J. G. Wood, M.A., LL.B., and edited by G. J. Symons, F.R.S. 8°. (1894).

TILLERY, W.—Meteorological Register kept at Welbeck Gardens, Nottinghamshire, 1827, 1838, 1842-4, 1846-71, and 1873-6. 4°. (MS.).

TIMBS, J.—Knowledge for the People. Part XVI. Meteorology. 12°. (1832).

VIRGINIA.—A geographical and political summary, embracing a description of the State, its geology, soils, minerals and climate. 4°. (1876).

WASHINGTON, DEPARTMENT OF AGRICULTURE.—Report of the Commissioner of Agriculture for the year 1865. 8°. (1866).

A RECORD OF THE GREAT FLOODS IN BATH and the surrounding district, Nov. 13 and 15, 1894. Reprinted from *The Bath Herald.* 4°. (1894).

APPENDIX V.

DONATIONS RECEIVED DURING THE YEAR 1894.

Presented by Societies, Institutions, &c.

ADELAIDE, OBSERVATORY.—Meteorological Observations made at the Adelaide Observatory and other places in South Australia and the Northern Territory ,1886-7.—Rainfall in South Australia, Aug. to Dec. 1893.

AGRAM, METEOROLOGISCHES OBSERVATORIUM.—Der Tornado bei Novska.

ALLAHABAD, METEOROLOGICAL Office.—Annual Statement of Rainfall in the North-Western Provinces and Oudh, 1893.

BARBADOS, COLONIAL SECRETARY'S OFFICE.—Returns of Rainfall in Barbados, Dec. 4, 1893, to Dec. 2, 1894.

BATAVIA, MAGNETICAL AND METEOROLOGICAL OBSERVATORY.—Observations, 1892.—Rainfall in the East Indian Archipelago, 1892.

BERLIN, DEUTSCHE METEOROLOGISCHE GESELLSCHAFT.—Berliner Zweigverein, 1894.—Meteorologische Zeitschrift, Dec. 1893 to Nov. 1894.

BERLIN, GESELLSCHAFT FÜR ERDKUNDE.—Verhandlungen, Band XX. No. 10 to Band XXI. No. 9.—Zeitschrift, Band XXVIII. No. 5 to Band XXIX. No. 5.

BERLIN, KÖNIGLICH PREUSSISCHES METEOROLOGISCHES INSTITUT.—Bericht über die Thatigkeit im Jahre 1893.—Ergebnisse der Beobachtungen an den Stationen II. und III. Ordnung im Jahre 1893, Heft 2, and 1894, Heft 1.—Ergebnisse der magnetischen Beobachtungen in Potsdam in den Jahren 1890 und 1891.—Ergebnisse der meteorologischen Beobachtungen, 1890.—Ergebnisse der Niederschlags-Beobachtungen im Jahre 1892.

BOMBAY, GOVERNMENT OBSERVATORY.—Magnetical and Meteorological Observations, 1891-3.

BOMBAY, METEOROLOGICAL OFFICE.—Brief Sketch of the Meteorology of the Bombay Presidency in 1893-4.

BOSTON, NEW ENGLAND WEATHER SERVICE.—Annual Summary, 1892.—Bulletin, Dec. 1893 to Oct. 1894.

BREMEN, METEOROLOGISCHE STATION.—Ergebnisse der meteorologischen Beobachtungen, 1893.

BRISBANE, CHIEF WEATHER BUREAU.—Observations at meteorological stations in Queensland, July to Sept. 1893.—Summaries of Rainfall in Queensland, Oct. 1892 to Sept. 1893.

BRISBANE, GENERAL REGISTER OFFICE.—Annual Report by the Registrar General on the Vital Statistics of Queensland, 1893.—Report on the Vital Statistics, Oct 1893 to Oct. 1894.

BRISBANE, ROYAL GEOGRAPHICAL SOCIETY OF AUSTRALASIA. (QUEENSLAND BRANCH).—Proceedings and Transactions, Vol. IX. 1893-4.

BRITISH NEW GUINEA, GOVERNMENT SECRETARY'S OFFICE.—Meteorological observations taken at Port Moresby, July to Dec. 1893.

BRUSSELS, OBSERVATOIRE ROYAL DE BELGIQUE.—Annales. Observations météorologiques d'Uccle, Jan. to June 1893.—Annuaire, 1894.—Bulletin météorologique, Dec. 1893 to Nov. 1894.

BUDAPEST, K. UNG. CENTRAL-ANSTALT FÜR METEOROLOGIE UND ERDMAGNETISMUS.—Jahrbuch, 1891.

BUCHAREST, INSTITUT MÉTÉOROLOGIQUE DE ROUMANIE. —Annales, Tomes VII.-VIII. 1891-2.—Buletinul Observatiunilor meteorologice din Romania, Dec. 1893 to Nov.1894.

CAIRO, SOCIÉTÉ KHÉDIVIALE DE GÉOGRAPHIE.—Bulletin, IVe. Série, Nos. 1 and 2.

CALCUTTA, METEOROLOGICAL DEPARTMENT OF THE GOVERNMENT OF INDIA.—Daily Weather Charts of the Indian Monsoon Area, July 28, 1893, to June 16, 1894.—India, Daily Weather Reports, Dec. 4, 1893, to Dec. 7, 1894.—Indian Meteorological Memoirs, Vol. VI. part 1.—Memorandum of the snowfall in the mountain districts bordering Northern India, and the abnormal features of the weather in India during the past five months [Jan. to May], with a forecast of the probable character of the South-west Monsoon rains of 1894.—Monthly Weather Review, Aug. 1893, to June 1894.—Rainfall data of India, 1893.—Registers of original observations, reduced and corrected, Aug. 1893 to June 1894.—Report on the Administration of the Meteorological Department of the Government of India, 1893-4.

CAMBRIDGE, U.S., ASTRONOMICAL OBSERVATORY OF HARVARD COLLEGE.—Investigations of the New England Meteorological Society, 1891.—Observations made at the Blue Hill Meteorological Observatory, Mass., 1892-3.—Observations of the New England Weather Service, 1892.

CAMBRIDGE, U.S., HARVARD UNIVERSITY.—Report of the Geological Department for the year 1892-3.

CAPE TOWN, SOUTH AFRICAN PHILOSOPHICAL SOCIETY.—Transactions, Vol. V. part 2, Vol. VII. part 1, Vol. VIII. part 1.

CARLSRUHE, CENTRAL BUREAU FÜR METEOROLOGIE UND HYDROGRAPHIE IM GROSSHERZOGTHUM BADEN.—Die Ergebnisse der meteorologischen Beobachtungen im Jahre 1893.—Niederschlagsbeobachtungen der meteorologischen Stationen im Grossherzogthum Baden, 1889, parts 1 and 2, 1893, parts 1 and 2, and 1894, part 1.

CHEMNITZ, KÖNIGL. SÄCHSISCHES METEOROLOGISCHES INSTITUT.—Jahrbuch, 1893, parts 1-3.

CHRISTIANIA, EDITING COMMITTEE NORWEGIAN NORTH ATLANTIC EXPEDITION, 1876-78.—Zoology, Ophiuroidea, by J. A. Grieg.

CHRISTIANIA, NORSKE METEOROLOGISKE INSTITUT.—Jahrbuch, 1892.—Oversigt over Luftens Temperatur og Nedboren i Norge i Aaret 1893.

COPENHAGEN, DANSKE METEOROLOGISK INSTITUT.—Bulletin Météorologique du Nord, Nov. 1893 to Nov. 1894.—Meteorologisk Aarbog, 1892, part 3, and 1893, parts 1 and 3.—Observations Internationales Polaires, 1882-3.—Expédition Danoise.—Observations faites à Godthaab sous la direction de A. F. W. Paulsen. Tome I., Livraison 1.

CORDOBA, ACADEMIA NACIONAL DE CIENCIAS. Boletin, Tomo XII. & XIII.

CORDOBA, OFICINA METEOROLÓGICA ARGENTINA.—Anales, Tomo IX.

CRACOW, K. K. STERNWARTE.—Meteorologische Beobachtungen, Aug. 1893 to July 1894.

CROYDON, MICROSCOPICAL AND NATURAL HISTORY CLUB.—Daily Rainfall in the Croydon district, Nov. 1893 to Nov. 1894.—Report of the Meteorological Sub-Committee for 1893.

DUBLIN, GENERAL REGISTER OFFICE.—Annual Report of the Registrar General (Ireland), 1892-3.—Weekly Returns of Births and Deaths, 1894.

DUBLIN, ROYAL DUBLIN SOCIETY.—Scientific Proceedings, Vol. VII. part 5, and Vol. VIII. parts 1 and 2.—Scientific Transactions, Vol. IV. part 14, and Vol. V., parts 1-4.

DUBLIN, ROYAL IRISH ACADEMY.—Proceedings, Third series, Vol. III. No. 2.—Transactions, Vol. XXX. parts 11-14.

EDINBURGH, GENERAL REGISTER OFFICE.—Quarterly Returns of the Births, Marriages and Deaths registered in Scotland, for the year ending Sept. 30, 1894.

EDINBURGH, ROYAL SCOTTISH GEOGRAPHICAL SOCIETY.—Scottish Geographical Magazine, 1894.

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Tinsley, G. W.—The vaster forces in Meteorology and Astronomy.

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Walker, E. O.—Earth Currents in India.

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Warry, Dr. J. K.—Reports on the Sanitary Condition of the Hackney District, 1889-92.

Williams, Dr. C. T.—Aero-Therapeutics.

Wilmhurst, A. J.—Temperature and Rainfall at Manor Park, Essex, Dec. 1893 to Nov. 1894 (MS.).

Woeikof, A.—Bemerkungen zu Hermann's Abhandlung: Beziehungen der Wetterkarten zur allgemeinen Cirkulation.—Bodentemperatur unter Schnee und ohne Schnee in Katherinenburg am Ural.—Das Klima und die Kultur.—Der höchste bis jetzt beobachtete Luftdruck auf der Erde.—Der Januar 1893 in Russland.—Der tägliche Gang der Temperatur und der Hydrometeore in Nordindien.—Gefrieren des Hudsonsflusses in Albany, Vereinigte Staaten.—Klimaschwankungen, resp. mehrjährige Perioden der Witterung und ihre Erforschung.—Klimatologische Zeit-und Streitfragen. I. Bemerkungen über den Einfluss von Land und Meer auf die Lufttemperatur. IV. Sind die Winter im Norden wärmer geworden? V. Kontinentales und ozeanisches Klima. VI. Abhängigkeit der Regen von der Aenderung des Querschnittes der Luftströme.—Mehrjahrige Schwankungen der Tiefentemperaturen des Genfersees und anderer Seen und Binnenmeere wärmerer Geganden.—Regenfall des südwestlichen Transkaukasien.

Woodd, B. T.—Charts from Richard Barograph at Conyngham Hall, Knaresboro,' 1893 (MS.).

Zenger, Prof. C. V.—Coup de foudre remarquable.—L'électricité considérée comme un mouvement tourbillonaire.—Le système du monde électrodynamique.

APPENDIX VI.

REPORTS OF OBSERVATORIES, &c.

The Meteorological Office. — Lieut.-Gen. R. Strachey, R.E., C.S.I., F.R.S., Chairman of Council; Robert H. Scott, M.A., F.R.S., Secretary; Nav. Lieut. C. W. Baillie, F.R.A.S., Marine Superintendent.

Marine Meteorology.—*Current Charts for all Oceans.*—The additions made to these charts during the year have consisted in the entry of any currents which have come in from recent voyages. Among these may be mentioned observations taken on board H.M. ships, and a series of observations from the Indian Ocean and Western Pacific, received from the Imperial Austrian Navy. The work of generalising the currents has now been undertaken; this is an operation requiring much consideration and judgment. It is not yet decided whether it will be advisable to bring out twelve monthly charts for each ocean, or whether (*e.g.*) quarterly charts will meet the requirements of sailors.

The Red Sea.—These charts are now complete, and will be issued in the course of the spring.

The Meteorology of the South Sea.—The extraction and discussion of materials has been finished, and the charts are now in process of preparation for the engravers.

The South Atlantic.—Good progress has been made with the examination and extraction of data. The region is very extensive, and the mode of treatment required will probably be different in different parts of the area.

The second edition of the *Barometer Manual for Seamen* has been published.

Weather Telegraphy.—The only addition to the Weather Reporting Stations during the year has been that the Swedish Government has forwarded reports from Carlstad on Lake Wener.

The Rain Tables for the British Isles for the decade 1881-90 are in the press. The values for England have been printed, and the information for Scotland and Ireland is less copious, so that it can soon be set up. The preparation of tables for back lustra, for such stations as were not contained in the previous publication, and for which data for periods earlier than 1881 exist, will now be proceeded with.

Land Meteorology of the British Isles.—The volume of *Hourly Mean Readings for five-day periods for the Four Observatories* in 1891 has not yet appeared, but that for 1892 is in an advanced stage, awaiting the completion of the hourly tabulation of sunshine, as mentioned in last year's Report.

Mr. Dines' pressure tube anemometer has been in action in the Office in London for two years, and it is now contemplated to erect some of these instruments at coast stations, as at Scilly or Holyhead, where there already exist other instruments, with which the indications yielded by Mr. Dines' apparatus can be compared.—*March 11th*, 1895.

ROYAL OBSERVATORY, GREENWICH.—W. H. M. Christie, M.A., F.R.S., Astronomer Royal.

The rapid gearing by means of which the registering sheet of Osler's anemometer could be made to travel at 12 times the ordinary speed having been found to work satisfactorily, a further change was introduced in the month of July enabling records to be made at a speed of 24 times the ordinary rate.

Numerous records have been made on this extended scale in high winds with satisfactory results, and the scale is now considered to be sufficiently opened out. Information relating to the gale of December 22nd has been furnished to Mr. C. Harding.

On account of the extension of the buildings for the north wing of the New Physical Observatory to the southern boundary of the Meteorological enclosure, it has been found necessary to remove the thermometer stand and the Stevenson screen to temporary positions near the north front of the photographic thermometer shed, but the final positions for these instruments have not yet been arranged. One rain gauge has also been shifted to a more open situation. Care has been taken to prevent interference to the instruments by workmen during the progress of building operations.

The abstracts of the observations of the temperature of the air for the 50 years 1841-1890 have been completely passed through the press, and the introduction (in the printer's hands) is alone wanting to complete this work, which will be now ready for issue in a very short time.

The mean temperature for the year 1894 was 49°·9, being 0°·5 above the 50 years' average. The maximum temperature was 86°·0 on July 6th, and the minimum 12°·8 on January 5th. The total amonnt of sunshine for the year was 1,052 hours, being 400 hours less than in 1893. The total rainfall amounted to 26·89 ins. on 192 days.—*April 8th*, 1895.

ROYAL OBSERVATORY, EDINBURGH.—Ralph Copeland, Ph.D., F.R.S.E., Astronomer Royal for Scotland.

The daily meteorological readings have been continued as in former years, together with weekly observations of the rock thermometers. The same large discrepancy as before is shown between the rain gauge on the roof and that on the grass 22 feet below, the upper gauge catching only 18·53 ins. in 1894, as compared with 28·02 ins. at the lower level.

It has not yet been practicable to begin observations at the new Observatory, but it is hoped that the meteorological instruments will be in full working order before the close of the summer.—*February 16th*, 1895.

KEW OBSERVATORY OF THE ROYAL SOCIETY, RICHMOND, SURREY.—Charles Chree, M.A., Superintendent.

The several self-recording instruments for the continuous registration of atmospheric pressure, temperature of air and wet-bulb, wind (direction and velocity), bright sunshine, and rain, have been maintained in regular operation throughout the year, and the standard eye observations for the control of the automatic records duly registered.

The tabulations of the meteorological traces have been regularly made, and these, as well as copies of the eye observations, with notes of weather, cloud, and sunshine, have been transmitted, as usual, to the Meteorological Office.

Early in the year a new "worm" spindle was fitted to the direction fans of the anemograph, and the square-headed pricker was replaced by a round one, made of extra hardened steel. At the same time the direction pencil was "trued" in the lathe to improve the marking, and later on the velocity spiral was similarly treated.

The analysis of the value of the residual corrections mentioned in last Report indicated that a re-determination of the barograph scale was expedient. This was carried out at the Meteorological Office, and showed that the old value of 1·569 ins. in the curve ordinates to 1 in. of pressure should be replaced by one of 1·553 ins. The new value has been employed since January 1st, and the irregularities of the residuals have been much less marked from that date.

The electrograph has been in regular action during the year, with the exception of about 11 days in January and 19 days in August, and its general performance has been satisfactory. Advantage was taken of the frost in January to dismount the whole of the instrument, to remove the old acid in the jar and insulators, and give the apparatus a general overhauling. At the same time the scale was slightly opened out. The suspension thread was accidentally broken on August 16th, but it was replaced, and the instrument re-started on September 4th.

Determinations of the scale value were made on March 30th, June 26th, and December 27th by direct comparison with the portable electrometer, White No. 53. The value of the scale divisions of this latter instrument was kindly determined by Prof. Carey Foster at University College Laboratory during February, and the value for one division found to lie between 197—205 volts. These experiments confirmed the scale value heretofore employed, viz. 1 scale division = 200 volts.

The observations of a series of distant objects, in fog and mist, have been continued. A note is taken of the most distant of the selected objects which is visible at each observation hour. An analysis of the results for the period May 1892 to December 1893 has been prepared and forwarded to the Meteorological Council.

At the instance of the Meteorological Council an electrical anemograph, with an improved arrangement for recording wind direction, has been under trial for some months.

To throw light on the results obtained with Lord Kelvin's water-dropper electrometer, a series of observations have recently been made for the Meteorological Office on the distribution of electric potential in the neighbourhood of the Observatory.

A grant of £30 has been obtained from the Royal Society Government Grant Committee for the purpose of conducting a research on the behaviour of aneroid barometers. The work of constructing the air pump and other apparatus required was entrusted to Mr. J. J. Hicks. He has unfortunately experienced considerable mechanical difficulties, which have delayed the construction of the apparatus. It is hoped, however, it will be ready for use at an early date.

During the year the temperature ranged from 14°·0 on January 5th, to 83°·4 on July 6th. The mean temperature was 49°·9. In the sun's rays (black bulb *in vacuo*) the maximum reading was 138° on July 8th; and the lowest reading of a thermometer freely exposed on the grass was 11° on January 5th and 6th.

1,851 hours of bright sunshine were recorded, giving a mean percentage of 29, which is the average value.

The only month calling for notice was March, when the percentage was 44, which is 15 per cent. above the average for the past 17 years, and the highest value yet obtained for that month.

The rainfall, 28·02 ins., is the heaviest since 1880. There were 3 daily falls exceeding an inch, viz. 1·11 ins. on July 10th, 1·43 ins. on July 29th, and 1·36 ins. on October 30th.—*March 1st*, 1895,

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RADCLIFFE OBSERVATORY, OXFORD.—E. J. Stone, F.R.S., Radcliffe Observer.

No change in the routine or staff has been made during the year. The gelatino-bromide paper has been used for the photographic registers; and the records of the photographic and self-recording instruments have been satisfactory throughout the year.

The eye-readings of the instruments have been taken as usual, and reports sent daily by telegram to the Meteorological Office, monthly to the Registrar-General and the local newspapers, and to sanitary and other authorities on request.

During the visit of the British Association to Oxford, the Observatory was thrown open to Members and Associates, and a large number availed themselves of the opportunity of visiting the Observatory.

The following are the chief characteristics of the weather noted at Oxford in the year 1894:—

The mean temperature of the air for the year was 49°·1, being 0°·3 above the

mean for the last 66 years. The highest temperature in the shade was 82°·5 on July 1st, and the lowest 11°·1 on January 5th, the difference being 71°·4. The highest temperature in the sun's rays was 131°·4 on July 6th, and the lowest on the grass 2°·5, on January 5th.

The total rainfall was 30·101 ins., being 3·853 ins. above the mean for the last 79 years. The largest monthly quantities of rain were 3·519 ins. and 4·964 ins. in October and November respectively; whilst from November 7th to 14th (inclusive) 4·346 ins. fell, resulting in extensive floods.—*February* 11*th*, 1895.

THE GALE OF DECEMBER 21st-22nd, 1894, OVER THE BRITISH ISLES.

By CHARLES HARDING, F.R.Met.Soc.

(Plate I.)

[Read January 16th, 1895].

It has been customary for some time past that the occurrence of any exceptional meteorological phenomenon should form the subject of a paper for reading at a meeting of the Society—a custom which has the advantage not merely of bringing out the special features in connection with the different phenomena, but as time goes on we are collecting a series of papers on various subjects which are of interest to the Fellows, and which may prove useful outside the immediate sphere of the Society. The present paper has been undertaken on the above grounds, and it has been treated much in the same manner as former papers which I have prepared on similar subjects.

The storm was one of exceptional severity over the northern portions of England and Ireland and in the south of Scotland. It developed energy very quickly, and travelled with great rapidity across the country. For some time previous to the storm gales were of frequent occurrence on our north and west coasts, and storm systems had been skirting our west and north coasts with great persistency, the disturbances following very much the same track when in close proximity to our coasts.

At 8 a.m. on December 21st the barometer was falling in nearly all parts of our Islands, and in Scotland and Ireland the fall in many places exceeded 0·3 in. since the preceding morning. The wind had backed from North-west to the Westward and South-westward, and the force had dropped decidedly, while rain had set in at many of the western stations. The Meteorological Office remarked that "Further depressions are approaching our western coasts, and mild unsettled weather seems probable over the United Kingdom generally, with freshening South-westerly winds on our western coasts." The barometer readings ranged from 29·54 ins. at Sumburgh Head to 30·20 ins. at Scilly and Prawle Point.

The 2 p.m. reports showed that the fall of the barometer was continued,

the decrease since 8 a.m. being greatest at Belmullet, where the fall amounted to 0·22 in. in the 6 hours. The rain area had considerably extended, but there was no material increase in the wind, Scilly being the only station reporting more than a fresh breeze, and there the wind was only force 6.

At 6 p.m. the fall of the barometer was still in progress over the entire Kingdom, and in the west the decrease was very rapid. The barometer was now as low as 29·34 ins. at Stornoway, while at Scilly the reading was 30·05 ins. The wind had everywhere become South-westerly and Southerly, and a fresh gale had already set in at Belmullet, while winds were freshening at all the western stations. The barometric fall was, however, as yet not rapid over the eastern portion of the Kingdom.

There was now ample evidence of an impending storm, and the following statement, based on the 6 p.m. reports, was issued by the Meteorological Office:

> "The depression which is approaching the west of Scotland is evidently of considerable depth, and is likely to occasion gales from the South-westward and Westward over nearly the whole of the United Kingdom, with heavy rain in some of the western and northern districts."

The storm-signals were at this time flying on all coasts.

At 8 a.m. on the 22nd the observations show that during the night a sudden and most important change had taken place. A large storm area had swept across the north of Scotland, and the centre was now over the North Sea, not far to the eastward of the Moray Firth. The barometric fall was exceedingly large, amounting to more than an inch at all the northern and north-western stations, and at Aberdeen the fall in the 24 hours, since 8 a.m. on the 21st, was 1·60 in. A very violent gale was blowing in all parts of the British Islands, the observer at Malin Head reporting force 12 of Beaufort's scale. The wind at this time had shifted to the North-westward in nearly all parts of the Kingdom. Under the influence of this large disturbance a gale was blowing in the Gulf of Bothnia and along the whole distance to the west coast of France, a distance of about 1,400 miles.

The 2 p.m. reports show that the disturbance was passing away quickly to the eastward, and a very decided rise of the barometer was in progress. The lowest reading now was 28·88 ins. at Sumburgh Head, while at Valencia the reading was 30·04 ins. The North-westerly gale was still blowing at many places on our coasts, but the wind was generally subsiding, although at Aberdeen force 11 was reported.

At 6 p.m. the wind was still further subsiding, although the gale was persistently blowing on the Irish and on our east coasts. The central area of the disturbance was now close to Christiansand on the coast of Norway, where the barometer was reading 28·55 ins., the core, or heart, of the storm having perceptibly shallowed or filled up.

At 8 a.m. on the 23rd, the wind had subsided over the whole of the British Islands, and the equilibrium seemed for the time to be thoroughly restored. There was no station in the United Kingdom reporting a stronger wind than a fresh breeze. The barometrical rise was equally as rapid as the

fall, the recovery since 8 a.m. of the 22nd being 1·65 in. at Aberdeen, and exceeding an inch at most of the northern and north-western stations.

I have made a collection of the anemograph records for different parts of the Kingdom, and give in Table I. the hourly velocities for 16 stations in the United Kingdom. The hourly velocities are given at each station for the whole time that the velocity was 45 miles or above at any station in any part of the Kingdom. In one part or another 45 miles an hour—a fresh gale, force 8 of Beaufort's scale—was maintained for 28 consecutive hours.

TABLE I.—WIND VELOCITY IN MILES PER HOUR, DECEMBER 21, 22, 1894.

Hour.	Valencia.	Dublin.	Armagh.	Orkney.	Aberdeen.	Alnwick.	North Shields.	Fleetwood.	Liverpool.	Holyhead.	Yarmouth.	Berkhamsted.	Greenwich.	Kew.	Falmouth.	Scilly.
21st																
10 p.m.	48	36	30	35	22	22	30	37	35	51	14	10	17	19	30	32
11 ,,	58	41	38	46	28	17	29	36	43	50	17	14	22	22	34	35
Midt.	59	46	46	48	26	23	39	38	36	57	19	16	26	26	38	42
22nd																
1 a.m.	56	32	48	44	25	28	47	49	40	58	22	20	28	29	42	43
2 ,,	56	32	44	40	29	42	54	55	46	64	25	21	32	35	46	46
3 ,,	57	33	44	41	30	47	55	71	54	51	28	20	30	40	46	47
4 ,,	61	29	38	33	26	62	47	76	63	52	31	24	36	40	40	46
5 ,,	59	33	42	31	25	62	52	79	66	55	34	26	41	40	34	52
6 ,,	53	31	43	17	21	79	57	86	72	58	35	30	40	33	34	52
7 ,,	58	28	40	10	11	72	61	97	76	58	32	25	31	22	39	52
8 ,,	50	30	36	54	19	60	57	101	81	59	32	31	34	29	37	52
9 ,,	43	33	27	76	35	45	45	107	79	66	38	29	37	28	34	52
10 ,,	40	28	29	82	39	48	37	103	78	65	37	30	40	30	37	50
11 ,,	31	25	25	83	56	61	45	104	89	68	44	34	46	36	44	56
Noon	38	31	21	77	60	65	55	99	80	71	49	40	50	36	43	48
1 p.m.	38	26	17	71	60	60	52	98	80	61	53	39	45	40	42	44
2 ,,	33	22	15	68	60	63	46	97	77	58	52	37	50	36	45	42
3 ,,	31	20	12	63	53	53	46	96	68	59	52	34	45	33	41	41
4 ,,	26	12	16	60	47	35	39	85	59	52	49	31	40	28	35	36
5 ,,	20	12	14	55	44	44	32	79	57	49	44	29	40	28	31	31
6 ,,	26	12	12	48	34	38	32	71	48	44	37	25	44	33	28	29
7 ,,	25	11	9	43	40	30	24	55	45	40	38	20	31	21	28	27
8 ,,	23	9	11	35	34	30	20	47	44	35	34	22	30	23	21	25

The factor 3 has been retained throughout this paper for the reduction of the anemometrical records, as no systematic change has yet been adopted either in this country or abroad, and the use of the factor 3 admits of ready comparison with all previous records. The numerous experiments, however, conducted in recent years by Mr. Dines and others, tend to show that the wind velocities obtained by the use of the factor 3 should probably be reduced by one-fourth to obtain the true velocity. The anemometers used are not all of the pattern known as the large Robinson; those at Dublin, Berkhamsted, and Scilly are of a smaller size.

The highest hourly velocity in Table I. is 107 miles, recorded at Fleetwood at 9 a.m. on the 22nd, and at that station the velocity exceeded 100 miles for the 4 consecutive hours from 8 to 11 a.m. This is the greatest force of wind

ever registered in the British Isles, and is 10 miles an hour in excess of the highest wind velocity in the great storm of November 16th-20th, 1893. The highest velocity previously recorded at Fleetwood was 91 miles an hour, in the gale of May 20th, 1887.

In my discussion of the Storm of November 16th-20th, 1893, a Table was given showing the dates of gales from 1869 to 1893, with a wind velocity of 80 miles an hour and upwards. That table shows that there have been 21 gales in the United Kingdom since 1869 in which the hourly velocity of the wind has attained 80 miles, and only 3 gales during the last quarter of a century in which the wind has attained a velocity of 90 miles an hour.

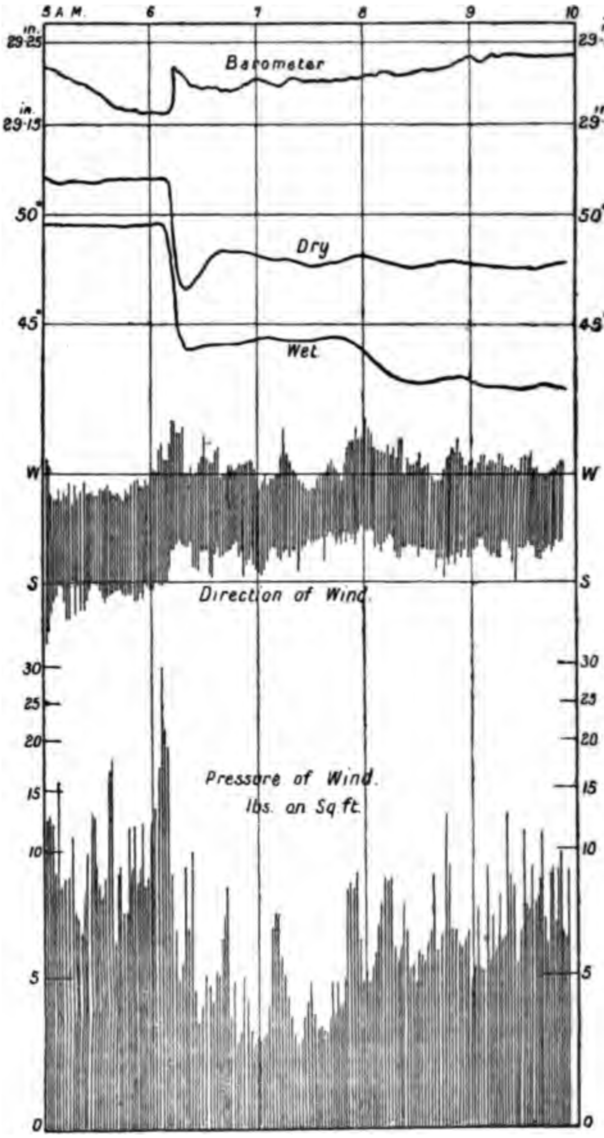
TABLE II.—FORCE OF WIND INDICATED BY VELOCITY ANEMOMETERS.

Station.	Maximum Velocity.				Hours with Velocity			Mean Hourly Velocity for 23 hours.
	Miles.	Direction.	Date.		45 Miles and above.	65 Miles and above.	85 Miles and above.	
Valencia	61	W	22	4 a.m.	11	...	...	43
Dublin	46	SSW	21	Midt.	1	...	...	27
Armagh	48	SW	22	1 a.m.	2	...	...	29
Orkney	83	NNW	22	11 a.m.	13	6	...	50
Aberdeen ...	60	NW and NWbN	22	Noon to 2 p.m.	6	...	...	36
Alnwick	79	S	22	6 a.m.	13	3	...	47
North Shields ...	61	SWbS	22	7 a.m.	14	...	...	44
Fleetwood	107	W	22	9 a.m.	20	16	11	77
Liverpool	89	W	22	11 a.m.	18	11	1	62
Holyhead	71	NWbW	22	Noon	20	4	...	56
Yarmouth	53	WbS	22	1 p.m.	5	...	...	35
Berkhamsted ...	40	W	22	Noon	...	...	...	26
Greenwich ...	50	WSW and W	22	Noon and 2 p.m.	5	...	...	36
Kew	40	SSW and WbN	22	3 to 5 a.m. and 1 p.m.	...	...	...	31
Falmouth ...	46	SWbS and SW	22 22	2 & 3 a.m. 11 a.m.	2	...	...	37
Scilly	56	WNW			11	...	...	43

Table II. gives a few of the principal details from Table I. grouped together for purpose of comparison. The highest velocities on shore are seen to have occurred at Fleetwood, Liverpool, and Orkney. These were the only places where the maximum hourly velocity exceeded 80 miles. At Alnwick the maximum was 79 miles, and at Holyhead 71 miles. The storm was least violent at Kew and Berkhamsted, where the hourly velocity did not exceed 40 miles. The gale was of longest duration at Fleetwood and Holyhead, the hourly velocity being 45 miles, and above, at each place for 20 hours, and at Liverpool that velocity was maintained for 18 hours. At Fleetwood the hourly velocity was 85 miles, or above, for 11 hours, and the average wind velocity for 23 hours was 77 miles.

Mr. R. H. Curtis has supplied the following note on the record of the Bridled anemometer at Holyhead :—

"The wind began to reach the force of a gale at 9 p.m. on the 21st, and by midnight the squalls had become very severe. It was essentially a squally gale, the velocity of the wind ranging over as much as 60 to 70 miles. The heaviest squall occurred from 10 a.m. to noon on the 22nd, and the maximum velocity recorded by the Bridled anemometer exceeded (more than once) 110 miles per hour (equal to 150 miles an hour on the basis of the old factor 3, C. H.),



Records at the Royal Observatory, Greenwich, December 22nd, 1894.

equivalent to a pressure of upwards of 36 lbs. per square foot. As early as 2 a.m. on the 22nd they reached a rate of 100 miles per hour (135 miles using factor 3, C. H.), but then fell off somewhat till between 4 and 5 a.m., when the force

increased again. After noon on the 22nd the wind fell away considerably, and after 2 p.m. no squall was experienced which much exceeded 80 miles per hour (108 miles using factor 3, C.H.), and during the evening the force became moderate."

Heavy squalls were a characteristic feature of the storm, and probably much of the damage and destruction to buildings on shore and to vessels at sea was due largely to this fact. A squall of exceptional violence passed over the Metropolis shortly after 6 a.m. on the 22nd. The Astronomer Royal has sent me tracings of the self-registering instruments at Greenwich, reproduced on p. 96, which show that this squall passed over the Royal Observatory at 6.10 a.m. A sudden rise occurred in the barometer of 0·06 in., accompanying a violent gust of wind of 28 lbs. on the square foot, and a fall of temperature exceeding 5° in amount.

The Kew records show the same squall, the instrumental readings giving the change at 6.5 a.m. The barometer rose 0·06 in., and the dry bulb

TABLE III.—RECORDS OF PREVIOUS GALES. MAXIMUM WIND VELOCITY IN MILES RECORDED IN ANY SINGLE HOUR.

Station.	1894. Dec. 21–22.	1893. Nov. 16–20.	1886. Dec. 8–9.	1886. Oct. 15–16.	1884. Jan. 26–27.	1881. Oct. 13–14.	1881. Jan. 18.
Valencia	61	60	72	58	68	58	46
Dublin	46	35	...	...	...	...	...
Armagh	48	31	...	21	69	24	...
Orkney	83	*96*	...	...	55	...	...
Aberdeen	60	46	59	45	59	*74*	...
Glasgow	...	44	34	34	50	33	...
Alnwick	79	44	44	36	*76*	...	...
North Shields	61	69	51	56	...	...	...
Fleetwood	*107*	87	*80*	42	...	...	...
Liverpool	89	49	...	38	...	...	...
Holyhead	71	89	72	62	70	...	...
Yarmouth	53	64	54	...	47	...	*83*
Berkhamsted	40	...	38	26	...	...	...
Greenwich...	50	35	...	40	58	63	...
Kew	40	38	42	32	53	45	58
Falmouth	46	55	61	59	63	57	54
Scilly	...	66	71	*78*	56	...	...

TABLE IV.—SHOWING THE FALL AND RISE OF THE BAROMETER DURING THE GALE.

Station.	Fall from 8 a.m. 21st to 8 a.m. 22nd.	Rise from 8 a.m. 22nd to 8 a.m. 23rd.
	in.	in.
Valencia	0·30	0·25
Malin Head	0·84	0·86
Donaghadee	1·01	1·09
Sumburgh Head	1·26	1·26
Stornoway	1·01	1·02
Aberdeen	1·60	1·65
Shields	1·49	1·57
Liverpool	1·01	1·10
Yarmouth	0·92	0·89
Scilly	0·46	0·53
Hurst Castle	0·66	0·74
London	0·77	0·85

temperature fell 6°·3. At Falmouth a precisely similar squall had occurred at 4.5 a.m. on the 22nd. The barometer rose about 0·05 in., the dry bulb temperature fell 5°, and the wind changed from South-west to West.

If this was one and the same squall, its rate of travel was about 120 miles an hour. The times of occurrence at Kew and Greenwich favour the possibility of this rapid movement.

Table III. (p. 97) gives the greatest force of the wind recorded in several recent gales.

The occurrence of the lowest reading of the barometer gives a good index of the direction in which the storm travelled. The following are a few of the best marked minima :—

Valencia - -	minimum at	11 p.m.	21st.
Waterford - -	,,	Midnight	,,
Kilkenny - -	,,	2 a.m.	22nd.
Stornoway - -	,,	6	,,
Freeland, Perthshire	,,	6	,,
Sumburgh Head -	,,	7.30	,,
Stobhill, Morpeth -	,,	8	,,
Ladylaw, Hawick	,,	8	,,
Aberdeen - -	,,	9	,,
Yarmouth - -	,,	Noon	,,

The following notes on the storm have been collated from the returns kept by special observers, who from their method of regular observation would be likely to give a true estimate of the severity of the storm.

SCOTLAND.

BRAEMAR.—Violent hurricane from 9 a.m. to 5 p.m. 22nd.

BALLINLUIG.—Heavy wind. Trees blown down.

LAUDALE, ARGYLLSHIRE.—Terrific gale overnight, at height from 6.15 a.m. till 8 a.m., when wind shifted from South-west to North. Equal not experienced since 1882. Timber blown down. Barometer began to rise at 6.15 a.m.

EDINBURGH.—Barometer fell to 28·12 ins. at 6 a.m. 22nd.

ARDROSSAN.—Strong South-west gale began about 8 p.m. 21st. Veering to North-west about 4 a.m. 22nd. The maximum wind force 11 in the gusts during early part of morning. It abated somewhat just before 2 p.m. The gale was exceptionally severe, the wind seemed to come down from above in gusts, striking the ground. The average force of 10 was maintained till 2 p.m. 22nd.

CARGEN, KIRKCUDBRIGHT.—The gale on the 21st and forenoon of the 22nd was the most disastrous we have had since the gales of December 1883 and January 1884 ; great damage has been done throughout the district, the greatest damage taking place between 10 and 11 a.m. on the 22nd, the squalls during that period amounting to almost hurricane violence.

LADYLAW, HAWICK.—Severe gale, heavy rain, centre of storm passed at 7.10 a.m.

IRELAND.

CARRABLAGH, LOUGH SWILLY, DONEGAL.—6 p.m. 21st, a storm devastated this district : it laid down trees, unthatched houses, smashed boats, stripped slates, and blew down stone walls in all directions. No such storm has been known here by living people.

ROCKFORT, BUNCRANA, DONEGAL.—Fearful gale on the night of 21st and following morning from South-west veering to North-west, did immense damage to shipping on Lough Swilly and to house property.

LONDONDERRY.—The rain gauge was blown away out of the garden on Saturday morning, 22nd, by the great storm of Friday night and Saturday morning. Nearly all the houses at the Waterside and the churches have been injured very much, and some partly blown down.

EDENFEL, OMAGH.—No storm since January 1839 has wrought such wide-spread havoc to buildings, and especially to plantations, as that of the night of Friday, 21st, and had its period of greatest violence lasted as long as on that occasion the damage to life and property would have been appalling.

OMAGH.—21st. At 8 p.m. a gale of cyclonic character rose, which increased in intensity and became almost a hurricane at midnight, and reached its period of greatest violence at 2.30 a.m., 22nd., doing immense damage. Wind South-south-east to West-north-west.

SPRINGFIELD, BELFAST.—Most severe storm on the 21st and 22nd. At 3.15 a.m. of the latter day a hurricane. Much damage done all over the country. Will be remembered hereafter as the great storm of 1894.

ARMAGH.—22nd. Great hurricane from midnight, maximum velocity of wind 48 miles about 1 a.m.

WARINGSTOWN, DOWN.—An awful storm on the morning of the 22nd, unequalled since 1839 ; great damage to roofs and buildings, and many trees blown down.

DUBLIN.—22nd. Violent gale from South-south-west to West-north-west last night and this morning. It was an extraordinary tempest, from the suddenness of its approach and its awful violence. Force 11 was reached at frequent intervals through the night, and some gusts merited the figure 12.

ENGLAND.

NEWCASTLE-ON-TYNE.—22nd. Gale this morning, very gusty, average velocity since about 11 p.m. yesterday equals 60 miles per hour.

CARLISLE.—This was a severe storm. It was a hurricane for 6 or 8 hours, say from midnight 21st to 8 a.m. 22nd, then a little easier.

DURHAM.—22nd. A whole gale blowing at times, 782 miles in 24 hours. From 9 a.m. to 3 p.m. it averaged 40 miles per hour.

BOLTON.—For a period of 4 hours the anemometer registered a lateral movement of 60 miles per hour, and as the velocity was very variable, it is probable the maximum speed would be 80 miles ; this would represent a maximum pressure equal to 32 lbs. per superficial foot.

ULDALE, CUMBERLAND.—The storm of 21st-22nd has done a lot of damage in this county, almost every house for miles round has suffered more or less, and the consequence is that there are so many demands upon the slaters and masons that it will be impossible for weeks to come to make good the damage done.

ULPHA, CUMBERLAND.—The gale on the 22nd was most disastrous, such a severe storm, causing so much damage, can hardly be called to mind.

WINDERMERE, WESTMORELAND.—The heaviest wind storm of the last 7 years, if at any time.

AYSGARTH, YORKSHIRE.—21st, between 7 and 8 p.m., wind began to rise from South-west with rain. At 9 p.m. it was raining hard and wind was South-west, force 7, barometer falling fast. Wind continued to increase, with heavy rain. It must have been force 10 by 2 a.m. at the least. About 7 a.m. the storm was very severe indeed, one could not put it at less than 12. Most of the damage was done at about this time. At 9 a.m. 22nd, it had shifted to West with a force of 11, and the barometer had begun to rise. Rain in night 1·5 in. Various damage reported, and a locomotive engine was said to have been capsized at Hawes Junction by the wind.

DOUGLAS, ISLE OF MAN.—The gale of 21st-22nd exceptionally severe, causing greater damage to buildings generally than any noted during the whole course of observations—upwards of 20 years.

STONYHURST.—22nd, a violent gale from midnight, wind velocity highest on record, maximum 9 a.m. 72 miles. Considerable damage done in surrounding district.

HUDDERSFIELD.—The gale of the 22nd was very severe, but here I think that those of October 14th, 1881, and December 8th, 1886, were certainly worse.

LLANDUDNO.—South-west 12 at 9 p.m. 21st.

HODSOCK, WORKSOP.—The gale on the 22nd did much damage to timber,

buildings, and stacks. For 8 hours, from 9 a.m. to 5 p.m., the average velocity of the wind was 60·5 miles per hour.

OXSHOTT, LEATHERHEAD.—The highest velocity by Mr. Dines's recording anemometer was 56 miles per hour, this occurred in a brief squall at 5.45 a.m. The gale here was not nearly so severe in any respect as that of December 12th, 1893. Very little damage was done.

The Railway disaster to the Manchester Express at Chelford was in a great measure attributed to the exceptional violence of the wind. A locomotive was reported as capsized by the wind at Hawes Junction, and several tramcars were upset in the Midlands. In Arran it is calculated that 40,000 trees were blown down by the gale.

A feature of some interest was the very great distance that the spray was carried inland, but this has been especially dealt with by Mr. Symons in *Symons's Monthly Meteorological Magazine.*

The Secretary of the Marine Department of the Board of Trade courteously allowed me access to the official returns, which show that there were 167 lives lost on our coasts within the limit of the *Wreck Chart*, and there was also great loss of life in the North Sea, not included in the above numbers; the total lives lost are those reported up to the morning of January 16th.

The Secretary of Lloyds, Col. Hozier, states that the 23rd being Sunday the Loss Book was not posted on that day. On Monday, the 24th, there were 110 casualties posted in the Loss Book, of which a large majority were due to the gale.

The National Lifeboat Institution state that the number of lifeboat launches during the gale was 43, the number of lives saved 103, and the number of vessels saved 2.

The *Pilot Chart of the North Atlantic Ocean* for January gives the track of the storm, which shows that it traversed the Atlantic at an enormous rapidity. It was first reported on the margin of the Tropics on December 18th, and on the following day it was to the south of Bermuda. (Plate I., fig. 6.)

In conclusion, I have to thank the Meteorological Council for having so kindly placed the whole of the material in the Meteorological Office at my disposal for the preparation of this paper, also Mr. Symons for handing over to me all the material relative to the storm which has come into his hands, and others who have so readily supplied me with data.

NOTE ADDED MARCH 20TH, 1895.

The gale of December 21st-22nd was followed by a very brisk rise of the barometer, and readings were for several days abnormally high. At Valencia the mercury stood at 30·93 ins. on December 27th, a reading which is the highest recorded there with a single exception. This was followed by another very severe gale on December 28th and 29th, the wind was, however, not so violent as on December 21st and 22nd, and the area affected was more limited. The maximum wind velocity was 83 miles an

hour at Fleetwood, the greatest violence being registered from the West-north-west at 7 a.m. 29th, and 45 miles an hour or above was maintained during the afternoon of the 28th and the whole of the 29th. At Alnwick the wind attained a velocity of 69 miles an hour from South-west-by-south at 2 p.m. 28th. At Armagh the velocity did not reach 30 miles an hour, and at Dublin the maximum velocity was 27 miles an hour.

DISCUSSION.

MR. G. J. SYMONS referred to a letter from Mr. H. S. Eaton enclosing a tracing which he had received of the deflections of a plummet suspended in a room at the summit of the Blackpool Tower (nearly 500 feet) during the prevalence of the gale described by Mr. Harding's paper. The observations were made by Mr. Ashley and Mr. Bell, and showed that the tower was deflected by the strength of the wind to the extent of about 2¼ inches. Mr. Symons further stated that he was in Liverpool when this great gale was blowing, and could speak as to its intensity by the amount of damage caused by the wind in that city. Some ten years ago, during a severe gale in the southern part of England, the foliage of trees was considerably damaged, and the question arose as to whether the injury was caused by the force of the wind twisting the stems to which the leaves were attached and so checking the flow of sap, or whether it was due to the deposition of salt brought from the sea by the wind. He (Mr. Symons) was disposed to consider that the damage was due to incrustation of salt upon the leaves, and it was curious to learn that, during the gale of last December, unmistakeable evidence was available showing to how great a distance inland the violent wind had carried sea-salt. A gentleman, a chemist, staying at Garstang, Lancashire, 10 miles distant from the sea, noticed on the day following the gale that the twigs and branches of trees, plants, grass, &c., tasted very strongly of salt. A fine drizzle subsequently set in, and some of the drops on the branches and twigs of apple trees were collected in a tea-cup, and the fluid so obtained was found to contain a very large proportion of salt. Half of the quantity of salt found was forwarded to him (Mr. Symons), and he sent it to Prof. Meldola for analysis, the result being that it was declared to be almost identical with sea-salt, the specific gravity of the liquid being nearly double that of sea-water. At Huddersfield, and at other places at a considerable distance from the sea, salt had been found upon the window panes facing the direction from which the wind blew, and even at a town so distant from the sea as Birmingham was, depositions of salt had been discovered.

ADMIRAL J. P. MACLEAR pointed out that the high velocities mentioned in the paper exceeded by 50 per cent. that given for a hurricane or typhoon in the Beaufort scale of wind force. He had experienced very severe typhoons in the China seas, and from what he had read concerning the gale on December 22nd, he did not consider that the force on that occasion was anything like the violence of a typhoon.

PROF. J. K. LAUGHTON remarked that, so far as he was aware, the extreme velocity of the wind in a tropical hurricane had never been measured: that commonly tabulated was merely an estimate, which, in view of actual measurements of storms of less intensity, must be considered much too small.

MR. W. H. DINES agreed with Mr. Harding in thinking it better to quote wind velocities obtained by using the factor 3, rather than to make the present uncertainty still worse by giving the correct values, but it would be a great advantage if he (Mr. Harding) would state in his paper which stations had anemometers differing from the Kew pattern. Recently he, Mr. Dines, had discovered that small cups and arms were in use at the Scilly Isles, and this had explained what had long been a puzzle to him, namely the comparatively low velocities recorded there. The record at Fleetwood, which, when corrected, gave a velocity of nearly 80 miles an hour, was most remarkable, and it seemed a wonder that any buildings were left. At Mauritius, Dr. Meldrum had noted a velocity of 105 miles per hour, lasting for five minutes, and in this instance half the town was destroyed, whereas 107 miles per hour lasting for an hour, and

100 miles maintained for four hours, had done comparatively little damag How could the discrepancy be accounted for? There was one other point he shoul like to mention. The bridled anemometer and his tube anemometer had bee calibrated on a whirling machine, and the velocities recorded by them wei absolutely independent of the factor of the Robinson instrument. He wished t state this fact most emphatically, since the mixing up of the two instrumen led to much misconception, so much so, that one gentleman in America ha written to ask him what factor he had used when calibrating the tub anemometer.

THUNDERSTORM AND SQUALL OF JANUARY 23rd, 1895

By WILLIAM MARRIOTT, F.R.Met.Soc.

[Read February 20th, 1895.]

Shortly before 10 a.m. on January 23rd, Londoners were startled by sharp thunderstorm and heavy squall, which passed rapidly across th Metropolis.

This squall was associated with a small depression, or secondary distur bance, which passed across the country in a south-south-easterly directior The first reported notice of thunder is from Leeds, where it was heard abou 6 a.m. From this time there appears to have been a succession of thunder storms all along the route, the last reported notice of thunder being fror Crowborough Beacon, in Sussex, at 10·25 a.m.

The first sign of anything unusual occurring was the intense darkness an thick fog, which came on suddenly, and these were followed immediately b lightning and thunder, and a heavy shower of hail; the wind also rising almos instantaneously to a gale. Damage by lightning occurred at Kettering an Oundle, and also at several places in and around London. Mr. Phillpot one of my assistants, states that when passing down Waterloo Place at 9·5 a.m. the lightning seemed to run along the side of the Duke of York's statu and that he heard a policeman say to a comrade that he heard a crackin sound proceed from the column.

The barograph traces show a rise or jump of ·05 inch, and the anemo graph curves indicate a simultaneous change in the direction of the win from West to North.

At the Meteorological Office in Victoria Street, Westminster, the Dine pressure tube anemograph sheet shows that the force of the wind ros almost at a bound from nearly a calm to a velocity of 36 miles an hour; an Mr. Dines's own anemograph at Oxshott recorded a similar gust of a velocit of 39 miles an hour.

The thermograph records show that there was also a sudden fall of in temperature.

The squall lasted about a quarter of an hour, and soon after the sun shone brightly, although the wind continued high for the greater part of the day.

The rate of travel of the disturbance was about 47 miles an hour.

The Astronomer Royal has kindly furnished me with a copy of the simultaneous changes of the barometer, dry and wet bulb thermometers, and the direction and pressure of the wind, at the Royal Observatory, Greenwich.

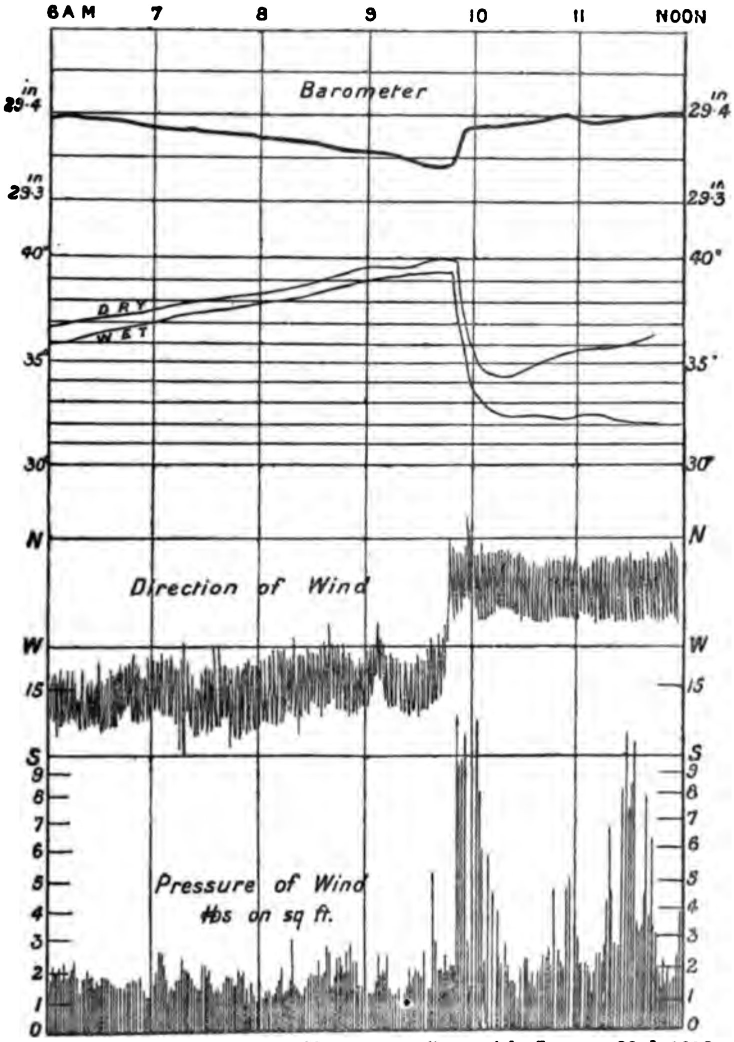


FIG. 1.—Records at the Royal Observatory, Greenwich, January 23rd, 1895.

These are reproduced in Fig. 1. The barometer is 159 feet above sea-level. It happened that the electrometer was switched to earth for its zero determination at the time of the squall, so that the indications of that instrument are not available for that time.

Mr. J. Bartlett has supplied the following account of destruction of trees at Bramley, near Guildford :—

"A snow blizzard of great intensity, but of short duration—little more than ten minutes—occurred here about 10.30 a.m. on January 23rd, the snow falling copiously while it lasted, and the force of the wind being, as I judge, rather over, than under, 9 of the Beaufort scale.

"Before noon on that day the Hon. H. Cubitt, M.P., of Birtley House, Bramley, knowing my interest in such matters, called and invited me to go and see the devastation of trees on his property, about half a mile distant from my house. He pointed out more than a dozen trees, some of large size, laid prostrate within a length of about 850 yards. Subsequently I heard of other like damage on his property near at hand, and also in Wonersh Park, belonging to Mrs. Sudbury. The total number of trees blown down, or, in two cases, seriously truncated, amounts to 28, some of great size, and within a length of 1860 yards. Mr. Cubitt was out with his gun, attended by his gamekeeper, in the open a few yards from the spot where five spruces were prostrated, the keeper being under cover near those trees. The former states that he had to run hard to the plantation in order to avoid being blown off his legs by the wind; and a man at work on a new building near at hand told me that he had to lie down to escape being blown from the scaffolding. On the other hand, an intelligent labourer told me that he was working with others at the time on Hurst Hill, in the open, some 500 yards to the westward, and that, although they heard the loud roar of the blast below, they felt comparatively little of it.

"Hearing the next day of considerable damage at Wonersh, I went thither, and was courteously shown by young Mr. Sudbury over the scene of destruction on that property. The four trees near Wonersh church, close to the Park, are at the very south-east foot of the considerable elevation of Chinthurst Hill. It would appear to me that the blast may have swept round each side of this hill, and joined forces again in the Park. A number of trees standing isolated on the summit of Chinthurst were uninjured.

"After careful inquiry, I can hear of no damage, other than what I have named, elsewhere in this vicinity, and Admiral Maclear informs me that nothing abnormal occurred at Cranleigh, 5 miles to the southward, beyond a very sharp outburst of wind, hail, and sleet. Thus the whole devastation was limited to a line of a little more than a mile in length."

Mr. Gaster has been kind enough to redraw for me the Weather Chart for 8 a.m. on the 23rd (Fig. 2). This shows that a depression passed over the Shetland Isles during the night of the 22nd, and that it had reached Denmark by 8 a.m. on the 23rd. The isobars at the latter time ran nearly north and south over the British Isles, and were somewhat close together, indicating the prevalence of strong Northerly or North-westerly winds. An irregularity in the direction of the wind and in one of the isobars is shown over the Midlands, and this agrees precisely with the position of the thunderstorm at that hour.

This particular storm may be classed under the head of "line" thunderstorms, as defined in my "Report on the Thunderstorms of 1888 and 1889," and is similar to the storms of May 18th-19th, 1888, and June 2nd, 1889, which I have already had the honour of bringing to the notice of the Society. In these latter cases a series of thunderstorms were tracked across England in a direct line from south to north for over 400 miles, the rate of progression being 50 miles an hour.

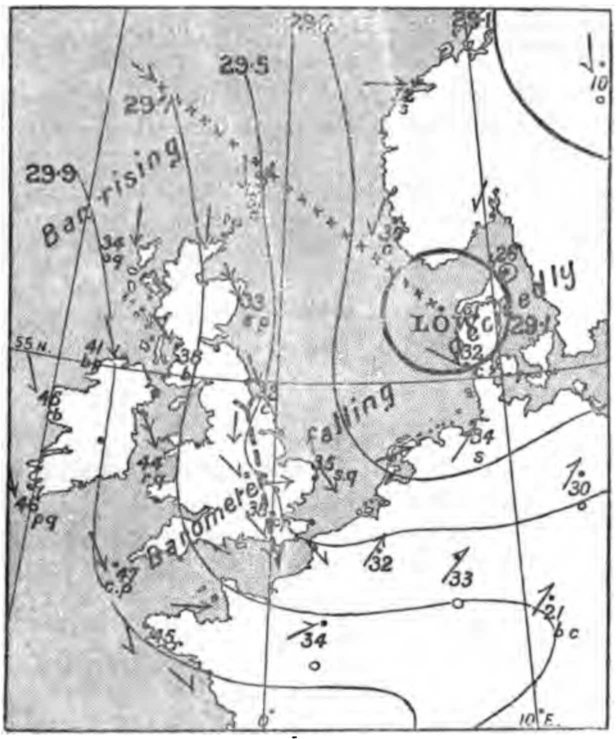


FIG. 2.—Weather Chart 8 a.m. January 23rd, 1895. The track of the Thunderstorm is also shown by the thick broken arrow.

The storm of January 23rd, 1895, however travelled in a south-south-east direction, the rate of progression being 47 miles an hour. In all these cases the thunderstorm disturbances were to the right of the main depression.

Mrs. H. S. Vinter has sent me the following extracts from the *Gentleman's Magazine* for 1767 of a thunderstorm which was followed (as was that of 1895) by a severe frost:—

Edinburgh, Jan. 3.

Last night we had a most remarkable storm of lightning attended with thunder, which continued from 9 in the evening till morning.

Whitby, Jan. 4.

On Thursday night we had here a most violent storm of wind and hail, coming from the NE, and blowing right into our harbour, causing the tide to rise near three feet perpendicularly higher than the oldest man living can remember.

Newcastle, Jan. 10.

Last Friday and Saturday we had a great fall of snow, with lightning and thunder.

Thursday, 8.

The snow was so deep throughout the whole Kingdom that the like has not been remembered by the oldest man living. . . . The post-boys have been bewildered, and some frozen to death.

Tuesday, 13.

The principal part of the flour destined for the supply of the London Market was on board barges and other vessels, which could not come down on account of the communication by water being stopt by the frost.

Friday, 16.

The post-boy who carried the mail from Bradford to Rochdale was with his horse frozen to death.

Mr. C. Harding has also called my attention to an account of a thunderstorm which occurred at the Royal Observatory, Greenwich, on January 3rd, 1841.

In the *Greenwich Observations* for that year there is the following note :— "From accounts received from various places, it appears that this was a travelling storm, passing from north to south, at the rate of 60 miles an hour, and it was nearly 100 miles in breadth ; its time of continuance at each place was nearly the same, and in every place it was preceded by a gale of wind, and accompanied with a heavy fall of rain, hail, and snow."

Note, March 5th.

At the Meeting of the French Meteorological Society on February 5th, M. Renou stated that at Parc-de-Saint-Maur, Paris, on January 23rd, two claps of thunder were heard to the north-west a little before 3 p.m. At Vendôme thunder was heard several times the same day; and at Châteaudun a church was struck by lightning.

DISCUSSION.

Dr. von Riche Preller observed that, having lately had to investigate, as Electrical Engineer, the effects of atmospheric electricity or lightning discharges in relation to electrical installations in various countries, he had also been led to inquire into the frequency of thunderstorms accompanied by lightning discharges both in the British Isles and in various parts of the Continent. Through the courtesy of Mr. Scott and Mr. Marriott, he had been able to examine the statistics of the last fifteen years; but he found that these statistics, valuable and excellent as they were *per se*, either referred only to particular storms, years, or isolated periods, or that they were annually compiled on principles which varied in every country, so that any attempt at comparing the frequency of such phenomena in any two countries gave a more or less negative result. The Royal Meteorological Society or the Meteorological Office would therefore render a signal service not only to meteorological, but to physical and electrical, science if, at the next International Congress, they would promote the adoption of a uniform international system of taking observations and compiling annual statistics of such phenomena. And in this connection, he might say that he thought the system adopted by Mr. Marriott in his valuable statistics of thunderstorms in England 1888 and 1889, (which is also the Swiss system,) viz. of recording the number of days on which such phenomena occurred, was at once more simple and more rational than, *e.g.* Signor Ciro Ferrari's plan of comput-

ing the percentage of thunderstorms in each district or province of any given country.

The other point to which Dr. Preller wished to refer related to thunderstorms and lightning discharges more especially in England. From the statistics and a great many isolated notices he had examined, he arrived at the conclusion that in England there were, broadly speaking, two lines or areas of greatest frequency of lightning discharges such as accompanied the thunderstorms of 1888, 1889, and 1892, to wit, one from London in the direction of Bristol, viz. east to west or *vice versa*, and the other from south to north or *vice versa*, through the western rather than the eastern parts of the country, and extending, probably, also along the western counties and coast of Scotland. These two lines, and notably the one east to west, coincided remarkably with the lines or areas of magnetic attraction on the north pole of the compass needle as determined by the surveys of Prof. Rücker and Prof. Thorpe, and explained by the former in a lecture recently delivered before the Royal Geographical Society. The coincidence of these lines, which, moreover, agreed with the general trends of the coal measures, was sufficiently striking, and Dr. Preller thought he might claim to have been the first to point it out on this occasion. He wished it to be understood that this coincidence applied, not necessarily to the path of all thunderstorms, which was determined by various other causes, but to the prevalence of lightning discharges along the two lines he had indicated.

Mr. J. Bartlett said that when investigating the damage done to the trees at Bramley, he was much struck by the isolation of the area, no other damage appearing to have been done in the neighbourhood. As a result of a letter inserted in the local paper asking for information concerning any damage at other places, he had received but one reply, from a gentleman at Sutton Green, Worplesdon, 8 miles north-west of Bramley, from which it appeared that a cart shed and barn were partially destroyed and some trees blown down at that spot.

Dr. A. Buchan said that he was in Clarendon Street, Pimlico, when the storm and squall discussed by Mr. Marriott occurred, and he believed that the interval between the thunder and lightning was less than one second. The darkness was intense, although the lower air stratum was clear, as windows opposite were distictly seen, but the roof of a three-story house was barely discernible. He had noticed in Edinburgh when a change of wind was coming on that darkness gathered in a certain part of the sky, which assumed a tawny hue, while the opposite portion of sky was clear and of an opalescent appearance. The thunderstorm and squall of January 23rd belonged, he believed, to the type of atmospheric disturbance which the Americans designate by the term "tornado." The whole phenomenon appeared to be due to the meeting of two air currents of different temperature and humidity.

Mr. F. C. Bayard inquired if it was correct to assume that a thunderstorm was to be always expected on the right-hand side of the track of an area of low pressure.

Dr. A. Buchan remarked that the satellite cyclone in which the thunderstorm is bound up is always on the right-hand side, and most generally to the south-south-eastwards of the main cyclone.

Mr. G. J. Symons said, that he believed that Northamptonshire was a county where lightning discharges were frequent: Oundle church had been repeatedly struck. The counties of Devon and Cornwall were generally exempt from damage by lightning, and he was inclined to think that the nature of the soil played some part in locating the areas of injury. The short time interval between the lightning and thunder in the storm of January 23rd was very remarkable, and appeared to be a particular feature of winter thunderstorms. At Camden Square the observations showed that the lightning discharges took place within half a mile, and the storm must therefore have been quite low in the atmosphere. He believed that winter thunderstorms were proportionately more destructive than those which occur in summer.

Mr. H. S. Wallis said that he had been struck by the fact that nearly everyone who described the storm spoke of the nearness of the lightning. At Camden Square only five flashes were seen and five peals of thunder heard, and the time interval showed them all to be within a distance of about a mile; he understood Dr. Buchan to say that he, at Westminster, saw only three flashes, all of which he estimated to be within a mile of him. It was therefore

evident that the flashes seen at Camden Square were invisible to Dr. Buchan, and the flashes seen at Westminster invisible and inaudible at Camden Square. It would appear that in this storm lightning could not be seen or thunder heard at a distance much exceeding a mile; and he thought that the two strata of air of very different temperature and humidity, mentioned by Dr. Buchan as causing the darkness, would account for this.

Mr. H. S. Eaton remarked that he was in Kensington when the storm occurred, and noticed that its arrival was preceded by the appearance of cumulo-stratus clouds such as are associated with summer thunderstorms.

Mr. W. Marriott, in reply, said that thunderstorms travelled with the wind along the isobaric lines. In the case of the storm of January 23rd the area of low pressure was in the east, and the thunderstorm travelled down the western side of it, following the direction of the isobars. He was not aware of any relation between the distribution of thunderstorms and the lines of terrestrial magnetism. Thunderstorm disturbances were regulated by the distribution of atmospheric pressure, and were most frequent over low-lying districts, often following the course of river valleys. The short time interval between the thunder and lightning, which was so noticeable a feature of the storm of January 23rd, was due to its low altitude in the atmosphere. Air temperature was also low, so the storm would not require to be very high in the atmosphere to give the decrement of temperature necessary for the formation of the hail which fell; summer thunderstorms were usually of greater altitude. He believed with Dr. Buchan that this thunderstorm was of the tornado type, and the sudden outburst of wind accompanying it appeared to support that view.

ON SOME GRADUAL WEATHER CHANGES IN CERTAIN MONTHS AT GREENWICH AND GENEVA.

By ALEX. B. MacDOWALL, M.A., F.R.Met.Soc.

(Plate 2.)

[Received December 5th, 1894.—Read February 20th, 1895.]

The variations, from year to year in a long series, of a given meteorological element, say, temperature, of the year or a part of it, are seldom long in the same direction (increase or decrease), and the curve representing such changes exhibits many zigzags. We may perceive, here and there, a distinct preponderance of higher values, and at other points of lower; and may accordingly picture to ourselves a series of longer waves, like an ocean swell which may be more or less obscured by the minor waves and ripples. Such longer waves may be rendered more evident by methods of smoothing or averaging; a curve being drawn in which each year point represents, not the actual value for that year, but the average of 3, or 5, or 7, or other number of yearly values.

It seems to me that a systematic investigation of the weather data of each month in this way, so as to bring into prominence the longer waves of variation, is calculated to yield many interesting results. Having done a

good deal of work of this kind, I have thought the following examples (of method and results) might be not without interest to the Society.

The features of weather considered are temperature, frost days, and rain days. It seemed desirable to make a comparison of Greenwich with some other European station, and I have selected Geneva; using the excellent record of the Observatory there, as communicated annually to the *Archives des Sciences*, along with M. Plantamour's *Nouvelles Etudes*, which summarise the figures from 1826 to 1875. For frost days at Greenwich I have utilised a table by Mr. C. Harding in the *Quarterly Journal* (1891, p. 113).

A considerable amount of similarity is usually found between corresponding smooth curves for Greenwich and Geneva, though either set presents, of course, some distinctive features.

We may begin with the temperature variations of *February*. The numbers of frost days in February at Greenwich since 1842, having been smoothed by means of averages of five, we obtain the dotted line curve in the first diagram[1] (Plate 2). The same smoothing process has been applied to those averages, giving the continuous curve. These curves are *inverted*, the lower parts representing the higher values.

Taking the twice smoothed curve (as we may call it) we note three long waves, culminating in 1850, in 1869 (19 years' interval), and in 1882 (13 years), mild Februaries preponderating at those points; while the lowest points are at 1855, 1874 (19 years), and in 1888 (14 years), cold Februaries preponderating.

Below are shown twice smoothed curves (alone) of frost days and mean temperature in February at Geneva since 1826 (the former curve being inverted). Here the recurrence of the same phases becomes somewhat more regular; the wave crests (at 1834, 1849, 1867, & 1883) showing an average interval of 16·3 years.

It is rather apart from my object in these remarks to suggest the existence of cycles; I have wished merely to present a picture of the actual variations in a given time. Nevertheless, this regularity may be pointed out as interesting.

The maxima and minima values of the 5-average in the case of Greenwich frost days may here be given.

The highest are as follows (in order of years):

1845.	1856.	1875.	1888.
14·4	14·4	13·2	16·6

and the lowest:

1850.	1869.	1883.
6·6	5·4	5·8

The range is thus between 5·4 in 1869 and 16·6 in 1888 (difference 11·2).

The case of *January* is presented in Fig. 2. The upper curve is a twice smoothed one of mean temperature at Geneva, while the second gives frost

[1] The vertical scale in these diagrams is varied according to convenience. Small letters (a, b, c,) indicate the vertical scale of each curve.

days at Greenwich (inverted) ; both the once-smoothed curve (dotted line) and the twice smoothed (continuous line).

Two features may here be noted : first, a curious recurrence in both curves at about 10 years interval (on an average). The Geneva curve has wave crests in 1835, 1843, 1853, 1866, 1875, and 1884 ; and the waves of the Greenwich curve are in fair agreement as to phase, while differing from each other in magnitude (low minima alternating, in the period considered, with high ones). Secondly, a gradual rise and fall in the Geneva curve, suggestive of a much longer wave, of which those 67 years apparently present only a part.

The variation of the 5-average for Greenwich is from 7·8 (in 1853) and 7·6 (in 1874) to 16·4 (in 1848), and 17·4 (in 1880), extreme difference 9·8.

Let us now turn to consider the cold of *November*. A pair of inverted curves is given in Fig. 3, made from the number of frost days in that month since 1841 ; the dotted line curve, as before, from a first smoothing (with 5-averages), and the continuous curve from a second. These seem to indicate a change of character in November. Since about 1860 it has on the whole become milder. Thus the 5-average of frost days in that year was 9·6. It has never been so high since, and in 1890 it was only 3·8. Curves of mean temperature give a corresponding result.

The Geneva curve of frost days (not given) also shows a fall, but of shorter extent.

These facts have, I think, a bearing on the subject of fog, which is known to be closely related to temperature. The statistics we have of fogs may be said to be somewhat 'foggy,' owing, it would seem, to some uncertainty as to what should be called a fog. We used to hear a good deal about November fogs, as if that month were the worst offender. This notion, however, appears to be exploded. According to Scott, Symons, and Brodie, who have each discussed the subject in recent years, November takes a place after December, January, and even October. Now Symons and Brodie deal with 20 years (from 1871), and Scott with 15 years (from 1876) ; and I would here submit that if we went a little further back than 1871 we should probably find a larger number of fogs in November, corresponding to the greater cold. Some time ago I went through the *Registrar General's Weekly Return* from 1858 to 1888, noting the cases in which fog was mentioned in the weather tables ; and the result gave November the highest place, though December came very close to it. And in the first half of that period of 31 years, the number of fog days was considerably greater (more than a third) than in the second half. Even if such an improvement in November has really taken place, I am afraid it would be vain to count on its permanency.

Another topic I propose to consider is, the number of *rain days* in the three months, *May*, *July* and *November*. The method here adopted is different, the figures being all smoothed with averages of 9.[1] On one side

[1] It may be stated that the method of twice smoothing with averages of 5 gives curves having in general the same features.

of Fig. 4 is shown the result in the case of Greenwich (from 1815), and on the other in the case of Geneva (from 1826).

There are some curious relations between these curves, to which attention is invited. And first, it is interesting, I think, to find these three Greenwich curves resembling each other so much. Thus, a low point is reached in each, about the end of the twenties or beginning of the next decade, then there is a rise to high values in the fifties; another minimum is reached in the sixties, and there is a general rise since. Further, it may be noted that two of the Geneva curves, May and July, have features similar to those just described, indicating that the influence to which such changes are due is not of a purely local character.

Again, the November curve, for Geneva, diverges from the common type, and presents evident differences from the November curve for Greenwich. Thus, the maximum of 1852, in the latter, is unrepresented; and from a minimum in 1847 there is, one may say, a long gradual rise throughout the remainder of the period.

Of the three months, July and November show the closer similarity in Greenwich; while May and July are more like each other in the case of Geneva. At Greenwich the number of rain days in November has risen since 1860 along with the temperature. Once more, the intervals appear to suggest Brückner's 35 years period. According to his view, 1815, 1850, and 1880 are approximately centres of cold and wet periods, while 1830 and 1860 are centres of warm and dry periods.

I will conclude with two well-marked examples of long gradual changes in the character of months. One is that of the mean temperature of July in Geneva; the other the mean temperature of April at both stations.

The July mean temperature curve for Geneva (in which the actual values are simply smoothed with averages of 5) is given in Fig. 5. Note the long gradual ascent from a value of 62°·2 in 1842 to one of 68°·9 in 1872. The corresponding curve for Greenwich (dotted line curve, with distinct scale) is somewhat different, with a low point reached in 1862.

With regard to April (Fig. 6), it will be observed that long changes of rise and fall have been in progress. For example, the Greenwich curve falls with little interruption from 51°·0 in 1867 to 46°·0 in 1890;[1] that of Geneva from 51°·2 in 1864 to 46°·6 in 1890.

Some interesting questions seem to arise out of the facts that have been presented.

One is as to the extent of the earth's surface over which those and other changes may be observed. Are they traceable over the whole of Europe, and on other Continents? A knowledge of their extent might materially affect our ideas on another question, that viz. as to their cause or causes. Why should our weather at a particular part of the year become in a long series of years gradually colder, wetter, &c.? The 35 years' period

[1] The values of mean temperature here used are those given in a recent table by Dr. Buchan in the Scottish Meteorological Society's *Journal* (3 Ser. No. 9).

(with which I have supposed some of those changes to be possibly connected), has been comprehensively studied by Brückner; but he does not appear to have obtained any light as to its causation.

Finally, it may fairly, I think, be considered whether those changes in the past do not afford some clues as to the future (in a general way). From a regular recurrence like that of Geneva frost days in February, might not a 'working hypothesis' be formed as to approaching waves of cold? The position now attained by such a curve as that of the November rain days seems to warrant us in expecting an early descent of the curve, &c.

To these, among other problems, I venture to invite the Society's attention.

REPORT ON THE PHENOLOGICAL OBSERVATIONS FOR 1894.

By EDWARD MAWLEY, F.R.Met.Soc., F.R.H.S.

[Read February 20th, 1895.]

Returns were received from 113 observers in 1894, or from four less than in the previous year. The distribution of the observing stations has however, somewhat improved, as there are now four observers in Ireland South instead of two, nine in Ireland North instead of six, and eight in England North-east instead of seven. For the new observers in Ireland the Society is indebted to the courtesy of the Editor of the *Irish Naturalist*, who inserted a letter from me in that Journal asking for new observers, with an editorial footnote requesting his readers to comply with my request.

The changes in the observing stations since the last Report was issued have been as follows:—No returns were sent in from Liskeard and West Bagborough in District **A.**; Wicklow in District **B.**; Bidborough, Lynsted, Bickley, Willinghurst, Croydon, Farley and Salisbury in District **C.**; Broxbourne, Walsall, Eaton and Bakewell in District **D.**; Wryde in District **E.**; Heswell in District **F.**; and Driffield in District **L.** On the other hand new stations have been started at Barnstaple in District **A.**; Ferns, Woodenbridge and Greystones in District **B.**; Whitchurch Canonicorum and Bere Regis in District **C.**; Hatfield in District **E.**; Ellesmere in District **F.**; Westport, Ballymena and Ramelton in District **G.**; and Great Cotes and Lilliesleaf in District **I.**

Most of the districts into which the British Isles are divided are moderately well represented, but new observers are still very much wanted in Ireland South and Scotland North and East.

At most of the stations the observations seem to have been made with considerable care, and in many cases the observers appear to take a keen interest in their work and endeavour to make their returns as complete and satisfactory as possible. Of the present staff about three-fourths of their number have sent in returns throughout the four years that the present system of observations has been adopted—most of these having from the commencement been among the Society's most trustworthy observers.

Table I. will show how satisfactory, on the whole, have been the returns sent in during the four years.

TABLE I.—MEAN RESULTS, WITH THEIR VARIATIONS FROM THE ADOPTED AVERAGE, FOR THE 13 PLANTS IN ALL THE DISTRICTS WHERE THERE HAVE BEEN SUFFICIENT OBSERVERS TO WARRANT COMPARISONS BEING MADE.

Years.	Eng. SW.		England, S.		Eng. Mid.		England, E.		Eng. NW.	
	Day of Year.	Variation from Average.	Day of Year.	Variation from Average.	Day of Year.	Variation from Average.	Day of Year.	Variation from Average.	Day of Year.	Variation from Average.
		Days.		Days.		Days.		Days.		Days.
1891	144	+13	144	+11	150	+14	147	+11	150	+13
1892	139	+ 8	138	+ 5	144	+ 8	143	+ 7	147	+10
1893	118	—13	122	—11	125	—11	123	—13	128	— 9
1894	126	— 5	130	— 3	135	— 1	127	— 9	137	Av.

The Winter of 1893-4.

December was a mild winter month in all the districts, the departures from the average in mean temperature ranging from $+1°\cdot8$ in England South to $+4°\cdot0$ in Scotland West and East. The first week or ten days in January proved very cold, especially in the Midlands, Ireland North, and Scotland East, but after this time unseasonably warm weather prevailed until the end of the month. With the exception of one week towards its close, when moderate frosts were experienced in most districts, the February temperatures were uniformly high. Taking the quarter as a whole the fall of rain in many parts of the British Isles was more or less in excess of the average. The record of sunshine, at all but the Scotch stations, also exceeded the mean.

The winter of 1893-4 was entered upon by farm and garden crops under very favourable circumstances. The soil, owing to the beneficial effects of the warm and dry summer of 1893 and the scanty vegetation of that year, was in a very fertile condition. The autumn sown cereals were sturdy and well-rooted, and thus well fitted to withstand any severe weather they might be called upon to encounter during the next three or four months. Fruit and other flowering trees and shrubs were furnished with exceptionally well ripened shoots, but on dry soils were in many cases still feeling the effects of the recent droughts. Early in January there occurred a brief but very keen frost, which appears to have been most severely felt in parts of Ireland and Scotland, where in many places evergreen shrubs were much crippled, and in some instances killed outright. In the neighbourhood

of Cork large areas of broccoli, growing in the market gardens, were completely destroyed. In the north Midlands also this frost, being preceded by cutting North-easterly winds, did much damage to shrubs and vegetables. But taking the country generally, little permanent harm was done to vegetation by this short spell of cold weather. No sooner was it at an end than a return to milder conditions took place, and although another cold week occurred in February the crops generally continued to make steady progress during the remainder of the season.

The hazel came into flower rather earlier than usual in the southern half of the Kingdom, but was late in the northern counties of England and in the west of Scotland. The flowering of the coltsfoot was also backward in the north, but about average in the warmer districts.

The song-thrush was heard at earlier dates than in either of the three previous years. The honey-bee first visited flowers at about the same time as in 1891 and 1893, but decidedly earlier than in 1892.

The Spring.

Throughout the whole of the British Isles both March and April were very warm months, but during May the weather became colder, and at the end of the third week there occurred on two successive nights frosts of exceptional severity for so late in the spring. March and April taken together had a deficient rainfall in all but the Irish districts, whereas in May the total fall was almost everywhere rather in excess of the mean. The first spring month proved in all parts one of brilliant sunshine, while April was also more sunny than usual; but during May, with the exception of Scotland East and North, where the weather continued bright, there was a deficiency of clear sunshine.

Farmers were enabled to work their land and prepare it for spring corn and roots under very favourable conditions, as the soil remained not only dry and friable, but also during a great part of the season unusually warm. The autumn sown cereals and grass also made good growth. In the gardens, until after the middle of May, the prospect of an exceptionally bountiful crop of fruit never perhaps before appeared so certain of realisation; for the trees and bushes were not only provided with young wood splendidly matured, but were heavily laden with fine healthy blossoms.

Unfortunately, on May 21st and 22nd there occurred two severe frosts, followed by keen North-easterly winds, which at once changed these brilliant prospects. The havoc committed among the fruit blossoms appears to have been very general, apples and strawberries being the greatest sufferers. No district entirely escaped this frost, and this was perhaps the most remarkable feature of it. Then again, although visiting nearly all parts of the kingdom, it is surprising how greatly the injuries resulting from it varied even within short distances, and how some localities were altogether untouched by it. Beyond giving a temporary check to their growth, this winterly weather did but little injury to the corn and grass. Potatoes, however, suffered severely in all parts of the country, and in the localities most

seriously affected beans, peas, and turnips and other like crops were also injured; while the oaks, ashes, horsechestnuts, and other trees had their young foliage entirely destroyed. By some observers the principal damage done to foliage and blossoms is attributed to the wind, while others say that it only affected trees, &c. situated in low-lying positions. Others again attribute it to the leaves and flowers being wet on one of the frosty nights, and some to the sun shining upon them when in a frozen condition. No doubt in many cases it was not the degree of cold alone, but one or more of the above influences combined with it, which caused the damage done to be greater than it otherwise would have been. Besides which, the cold winds which followed the frost must have greatly increased the injuries it inflicted, Taking the means of all the extreme minima at the Meteorological Office stations for the different districts during the May frost, and beginning with those which come out with lowest temperatures, they arrange themselves as follows:—Scotland East (**J.**), Scotland North (**K.**), England Midlands (**D.**), Scotland West (**H.**), England North-east (**I.**), Ireland North (**G.**), England East (**E.**), England North-west (**F.**), England South-west (**A.**), Ireland South (**B.**), and England South (**C.**); the means ranging from 28°·5 in Scotland East to 34°·6 in England South.

The wood anemone came into blossom from ten days to three weeks late. But the flowering of all the spring plants after this, until the third week in May, took place decidedly early, and in some cases earlier even than in 1893. For instance, the blackthorn was in bloom from a week to ten days in advance of the mean in most parts of the country; garlic hedge mustard ten days to a fortnight, and the horsechestnut and hawthorn from a fortnight to three weeks earlier than usual; whereas the white ox-eye, which flowered after the middle of May and in the beginning of June, varied from about average to less than a week early in the first six districts, and was from a week to three weeks late in the more northern ones.

The spring migrants made their appearance in this country as a rule in advance of their usual time:—The swallow at an earlier date than in either of the three preceding years, except 1893; the cuckoo four days earlier than in the previous spring, and nearly a fortnight earlier than in either 1891 or 1892. The dates for the nightingale and flycatcher are also very early ones.

As in 1893, wasps and the small white butterfly were first seen unusually early in the year, but the orange tip butterfly, although also early, made its appearance somewhat later than in the previous year.

The Summer.

With the exception of the last week June was a cold summer month. July began with a hot week, and there was a little warm weather at its close, but during the rest of the month the temperature remained below the average, while August proved cold throughout. Taking the summer as a whole, the temperature was below the average in every district except Scotland North, where the July mean compared with average comes out as +2°·3. In nearly all parts of the Kingdom the summer was a wet one,

TABLE II.—LIST OF OBSERVERS.

Station.	County.	Height above sea-level.	Observer.
A.		Ft.	
1 Marazion	Cornwall	40	F. W. Millett
2 Mawnan Smith	Cornwall	200	Miss R. Barclay
3 Falmouth	Cornwall	190	Miss Willmore
4 Tiverton	Devon	270	Miss M. E. Gill
5 Westward Ho	Devon	100	H. A. Evans
6 Instow	Devon	250	H. M. W. Hinchliff
7 Barnstaple	Devon	20	T. Wainwright
8 Sidcot	Somerset	200	W. F. Miller C. B. Rowntree
9 Long Ashton	Gloucester	280	Miss H. Dawe
10 Clifton	Gloucester	300	G. C. Griffiths, F.E.S.
11 Penarth	Glamorgan	120	G. A. Birkenhead
12 Cardiff	Glamorgan	40	A. Pettigrew
13 Castleton	Glamorgan	80	F. G. Evans, F.R.Met.Soc.
14 Bassaleg	Monmouth	25	W. J. Grant
15 St. Arvan's	Monmouth	360	Miss M. Poake
16 St. David's	Pembroke	220	W. P. Propert, LL.D., F.R.Met.S
17 Aberystwith	Cardigan	30	J. H. Salter, B.Sc.
B.			
18 Killarney	Kerry	100	Ven. Archdeacon Wynne
19 Ferns	Wexford	260	G. E. J. Greene, D.D., F.L.S.
20 Woodenbridge	Wicklow	300	J. Hunter
21 Greystones	Wicklow	20	Mrs. W. Wynne
C.			
22 Bembridge	Isle of Wight	80	C. Orchard
23 Whitchurch, Canonicorum	Dorset	150	Miss Mules
24 Bere Regis	Dorset	130	W. Bedford
25 Blandford	Dorset	270	J. C. Mansell-Pleydell, F.G.S., F
26 Buckhorn Weston	Dorset	290	Miss H. K. H. D'Aeth
27 Pennington	Hants	100	Miss E. S. Lomer
28 Strathfield Turgiss	Hants	200	Rev. C. H. Griffith
29 Bexhill-on-Sea	Sussex	10	H. Le M. Dunn
30 Muntham	Sussex	250	P. S. Godman, F.Z.S.
31 Dover	Kent	150	F. D. Campbell
32 Farnborough	Kent	350	F. G. M. Kelly
33 Swanley	Kent	220	C. H. Hooper
34 Chislehurst	Kent	360	Miss F. Duncan
35 Coneyhurst	Surrey	600	J. Russell
36 Churt Vicarage	Surrey	350	Rev. A. W. Watson
36 Churt	Surrey	300	C. Criddle
37 Cranleigh	Surrey	180	Admiral J. P. Maclear, F.R.Met.
38 Winterfold	Surrey	580	R. Turvey
39 Oxshott	Surrey	210	W. H. Dines, B.A., F.R.Met.Soc
40 Ashtead	Surrey	..	R. M. Prideaux
41 Addlestone	Surrey	100	C. U. Tripp, M.A., F.R.Met.Soc.
42 East Molesey	Surrey	40	Lady Jenkyns
43 Marlborough	Wilts	480	E. Meyrick
44 Whatley	Somerset	450	C. G. Whittaker
45 Whitchurch	Oxford	150	Rev. J. Slatter, M.A., F.R.Met.S
46 Reading	Berks	..	H. Goadby
D.			
47 Oxford	Oxford	200	F. A. Bellamy, F.R.Met.Soc.
48 Cheltenham	Gloucester	250	M. L. Evans
49 Beckford	Gloucester	120	F. Slade, F.R.Met.Soc.
50 Watford	Herts	240	Mrs. G. E. Bishop
51 St. Albans (The Grange)	Herts	380	Mrs. Hopkinson

TABLE II.—LIST OF OBSERVERS—*Continued.*

Station.	County.	Height above sea-level.	Observer.
D.		Ft.	
51 St. Albans (Ad-discombe Ldg.)	Herts	400	Miss E. F. Smith
51 St. Albans (Worley Road)	Herts	300	H. Lewis
51 Radlett	Herts	320	Miss E. M. Lubbock
52 Berkhamsted	Herts	400	Mrs. E. Mawley
53 Harpenden	Herts	370	J. J. Willis
54 Ross	Hereford	210	H. Southall, F.R.Met.Soc.
55 Breinton	Hereford	230	H. A. Wadworth, F.R.G.S.
56 Evesham	Worcester	120	Rev. D. Davis, B.A.
57 Henley-in-Arden	Warwick	320	T. H. G. Newton, F.R.Met.Soc.
58 Northampton	Northampton	320	H. N. Dixon, M.A., F.L.S.
59 Churchstoke	Montgomery	550	P. Wright, F.R.Met.Soc.
60 Burbage	Leicester	430	C. C. Hurst, F.R.H.S.
61 Thurcaston	Leicester	250	Rev. T. A. Preston, F.R.Met.Soc.
62 Uppingham	Rutland	300	G. W. S. Howson, M.A.
63 Tean	Stafford	470	Rev. G. T. Ryves, F.R.Met.Soc. Miss M. G. B. Ryves
64 Beeston	Notts	210	G. Fellows, F.R.Met.Soc.
65 Hodsock	Notts	60	Miss Mellish, F.R.H.S.
66 Macclesfield	Cheshire	500	J. Dale
67 Belton	Lincoln	200	Miss F. H. Woolward
68 Harrogate	Yorkshire	340	J. Farrah, F.R.Met.Soc.
E.			
69 Hatfield	Herts	..	T. Brown
70 Hertford	Herts	140	W. Graveson
71 Hitchin	Herts	230	J. E. Little, M.A.
72 Ashwell	Cambridge	260	H. G. Fordham
73 Bocking	Essex	240	H. S. Tabor, F.R.Met.Soc.
74 Lexden	Essex	90	Miss Carver
75 Sproughton	Suffolk	30	Rev. A. Foster-Melliar
76 Tacolneston	Norfolk	190	Miss E. J. Barrow
F.			
77 Ellesmere	Shropshire	300	J. A. S. Jennings
78 Penmaenmaw	Carnarvon	350	A. T. Johnson
79 Claughton	Lancashire	80	Mrs. K. Green
80 Giggleswick	Yorkshire	500	E. Peake, M.A.
81 Ambleside	Westmoreland	320	S. A. Marshall
82 Egremont	Cumberland	160	J. Sherwen
83 Cronkbourne	Isle of Man	110	A. W. Moore J. Murphy
84 Orry's Dale	Isle of Man	70	Miss C. G. Crellin
85 Sulby	Isle of Man	80	H. S. Clarke, F.E.S.
G.			
86 Edgeworthstown	Longford	270	J. M. Wilson, B.A.
87 Westport	Mayo	10	J. M. McBride
88 Loughbrickland	Down	350	Rev. H. W. Lett, M.A.
89 Saintfield	Down	310	Rev. C. H. Waddell, M.A.
90 Antrim	Antrim	70	Rev. W. S. Smith
91 Ballymena	Antrim	150	W. Anderson
92 Londonderry	Londonderry	450	T. Gibson
93 Ballynagard	Londonderry	30	Miss A. M. Campbell
94 Ramelton	Donegal	200	Miss K. Swiney
H.			
95 Dalshangan	Kirkcudbright	500	T. R. Bruce
96 Tynron	Dumfries	520	J. Shaw
97 Thornhill	Dumfries	300	J. Fingland
98 Jardington	Dumfries	100	J. Rutherford
99 Helensburgh	Dumbarton	100	Miss Muirhead

TABLE II.—LIST OF OBSERVERS—*Continued.*

Station.	County.	Height above sea-level.	Authority.
I.		Ft.	
100 Doddington	Lincoln	90	Rev. R. E. Cole
101 Great Cotes	Lincoln	..	J. Cordeaux
102 Thirsk	Yorks (N. R.)	120	A. B. Hall
103 East Layton	Yorks (N. R.)	570	Mrs. E. O. Maynard Proud
104 Durham	Durham	350	H. J. Carpenter
105 Low Fell	Durham	90	A. W. Price
106 Cambois	Northumberland	20	S. Dunnett
107 Lilliesleaf	Roxburgh	530	Miss O. R. Carre
J.			
108 Aberdeen	Aberdeen	40	P. Harper
K.			
109 Inverbroom	Ross	50	J. A. Fowler

The numbers before the names of the Stations refer to their position on the map of the Stations (Fig. 1, p. 119).

while there was everywhere a marked deficiency of bright sunshine, except in the north of Scotland, where the weather appears to have been remarkably sunny.

In the earlier districts most of the hay was harvested in splendid condition, and as was the case everywhere, the crop proved an unusually heavy one; but in the later districts rain greatly interfered with its ingathering. The corn made slow but satisfactory progress until warmer weather set in for a time at the end of June, after which it grew more rapidly and very strongly. Much of this fine crop was, however, beaten down by the heavy thunderstorms of July and August. The corn harvest was a very long and tedious one, owing to the many interruptions caused by the frequent rains.

Weeds, as might have been expected in such a cool wet summer, grew apace, and were with difficulty kept under. Slugs and snails were unusually numerous and destructive. But the pests of the season were undoubtedly aphides of all kinds, which did considerable mischief to fruit and other trees, roses, &c. Earwigs were also very numerous in East Anglia and other parts. There were, however, very few wasps or butterflies anywhere to be seen.

Owing to the May frosts there was almost everywhere a very scanty crop of strawberries. Raspberries, currants and gooseberries also yielded badly, especially in the midland and northern counties of England and in Scotland.

The dog-rose flowered at about its average date in all the first six districts except England East, where it was early, but was decidedly late in most of the northern districts. The flowering of the black knapweed, the harebell and the greater bindweed was very irregular, but in the case of the two last named was in most parts of the country rather in advance of the mean.

The meadow brown butterfly made its appearance later than in any year since 1891.

The Autumn.

Septemb r proved everywhere a cold month, but in October there were a good many moderately warm days, and during November the weather remained throughout unseasonably mild in all parts of the country. The

Fig. 1.—Map showing the position of Phenological Stations, 1894. For the Names of the Stations, see List of Observers, Table II.

total rainfall of this quarter was large in the South and South-west of England, but by far the greater part of it was deposited during the three weeks ending November 14th, which were excessively wet. In most of the other districts the fall varied from about average to over 4 inches in

TABLE III.—DATE (DAY OF YEAR) OF FIRST FLOWERING OF PLANTS, 1894.

Station.	Hazel.	Coltsfoot.	Wood Anemone.	Blackthorn.	Garlic Hedge Mustard.	Horse Chestnut.	Hawthorn.	White Ox Eye.	Dog Rose.	Black Knapweed.	Harebell.	Greater Bindweed.	Ivy.
A.													
Marazion	30	34	..	63	..	114	109	*160*	141	192	..	196	267
Mawnan Smith ..	20	..	83	62	..	110	117	141	160	..	..	..	267
Falmouth	34	47	..	57	..	101	102	147	..	..	..	..	..
Tiverton	27	44	82	81	95	111	110	135	144	158	..	..	..
Westward Ho	..	46	..	..	92	..	..	..	..	186	..	..	..
Instow	..	..	82	82	98	105	100	..	..	..	..	..	..
Barnstaple	28	51	75	71	89	105	113	140	154	170	..	169	277
Sidcot	1	34	62	85	94	99	116	138	149	..	..	186	252
Long Ashton	..	..	..	..	..	113	121	..	161	..	168	..	289
Clifton	..	..	82	90	..	103	111	..	..	..	..	..	270
Cardiff	22	40	..	84	..	101	110	..	158	..	..	201	274
Castleton	21	34	72	76	94	96	113	125	146	183	200	192	260
Bassaleg	20	52	86	83	..	96	106	139	160	..	..	181	268
St. Arvans	30	..	81	89	101	108	122	144	..	179	203	199	263
St. David's	..	64	..	77	..	..	..	..	..	..	..	203	..
Aberystwith	20	55	77	..	89	104	105	122	132	164	..	164	263
B.													
Killarney	14	46	67	50	101	93	98	130	150	200	..	191	244
Ferns	..	..	61	79	*146*	106	115	142	151	..	..	155	..
Woodenbridge	..	..	..	..	..	111	118	124	165	..	..	208	268
Greystones	..	35	..	69	..	107	117	..	..	..	..	..	..
C.													
Bembridge	26	20	..	86	98	109	109	127	..	..	..	..	..
Whitchurch, Canonicorum	21	39	66	79	94	115	106	125	153	160	..	196	..
Blandford	17	61	78	78	..	115	125	135	..	191	175	201	301
Buckhorn Weston	22	51	75	85	94	111	106	132	150	165	..	181	276
Pennington	23	62	..	85	100	102	121	124	154	159	159	..	280
Strathfield Turgiss	32	51	70	87	95	109	112	135	155	169	160	175	255
Bexhill-on-Sea	41	..	71	90	105	107	102	130	139	..	..	..	293
Muntham	29	47	78	82	100	108	100	129	147	172	..	218	266
Dover	..	39	..	88	..	103	122	..	163	182	..	..	280
Farnborough	34	51	..	89	91	113	107	134	161	..	..	..	..
Chislehurst	21	58	84	83	110	111	116	136	156	..	195	171	285
Coneyhurst	..	..	79	88	111	120	118	130	150	..	196	202	283
Churt (Vicarage) ..	20	81	83	90	101	121	116	144	162	..	158	..	..
Churt	14	58	83	84	99	102	116	135	144	157	166	201	*234*
Cranleigh	29	..	75	83	97	103	106	142	154	166	..	188	285
Winterfold	29	33	..	..	..	118	128	145	150	*214*	197	..	276
Oxshott	39	..	82	89	103	118	110	..	162	..	..	..	..
Ashtead	41	56	..	94	103	116	129	151	147	196	..	..	..
Addlestone	31	79	98	90	99	104	112	142	155	180	192	195	..
East Molesey	35	61	..	88	106	106	115	..	159	175	..	204	269
Marlborough	20	39	69	76	101	120	118	142	151	174	188	..	262
Whatley	33	..	84	99	104	110	125	145	168	188	..	..	..
Whitchurch	21	..	..	..	..	..	..	..	..	..	..	..	..
Reading	44	71	90	77	..	..	..	..	..	..	..	..	..
D.													
Oxford	32	71	..	87	94	107	115	143	145	173	..	..	251
Cheltenham	26	62	70	82	103	110	117	152	155	..	200	209	251
Beckford	28	57	84	81	104	106	110	121	150	..	..	..	258
Watford	34	74	89	85	110	120	121	150	153	..	..	..	284
St. Albans (The Grange)	34	..	77	89	104	110	118	147	..	..	..	..	289
St. Albans (Ad. Lge.)	30	62	..	66	100	103	116	118	159	180	200	223	293
Radlett	38	..	..	88	110	108	121	..	..	..	..	..	..

TABLE III.—Date (Day of Year) of First Flowering of Plants, 1894—*Continued.*

Station.	Hazel.	Coltsfoot.	Wood Anemone.	Blackthorn.	Garlic Hedge Mustard.	Horse Chestnut.	Hawthorn.	White Ox Eye.	Dog Rose.	Black Knapweed.	Harebell.	Greater Bindweed.	Ivy.
D.													
Berkhamsted	39	58	89	89	99	116	*133*	152	150	187	201	187	289
Harpenden	30	60	..	87	102	113	115	126	154	..	..	.	..
Ross	42	42	..	..	103	107	103	..	..	..	..	..	..
Breinton	40	55	81	86	97	114	113	120	146	182	190	195	274
Evesham	37	61	*98*	86	..	..	102	131	152	*212*	..	177	289
Henley-in-Arden ..	*56*	48	83	88	*121*	110	118	..	152	..	..	..	..
Northampton	41	60	76	91	108	113	115	132	166	182	186	219	265
Churchstoke	45	70	80	86	103	117	125	143	168	192	194	200	301
Burbage	29	44	84	96	..	118	120	..	*181*	..	..	..	..
Thurcaston	38	39	90	89	103	119	115	159	159	177	..	222	..
Uppingham	44	62	79	86	109	116	115	132	152	..	195	..	..
Tean	31	87	..	93	..	..	128	163	..	..	188	..	..
Beeston	31	66	..	87	..	121	119	156	170	176	175	..	..
Hodsock	13	37	87	85	104	112	122	156	169	187	192	187	273
Macclesfield	38	65	85	99	..	115	116	160	165	187	188	196	274
Belton	23	58	72	87	112	..	116	143	168	183	203	209	..
Harrogate	–1	55	84	90	106	122	*141*	165	174	186	188	192	308
E.													
Hatfield	..	..	88	86	..	104	111	..	150	..	..	..	..
Hertford	18	39	70	67	95	110	102	130	144	161	193	191	259
Hitchin	34	35	76	79	98	103	103	131	140	168	179	193	271
Ashwell	19	58	..	83	..	115	110	..	..	..	..	..	..
Bocking	29	65	91	93	105	107	124	157	157	*210*	..	..	248
Lexden	34	..	74	91	101	101	114	..	148	..	..	..	266
Sproughton	30	..	..	..	104	113	115	135	151	..	..	..	291
F.													
Ellesmere	49	63	81	..	105	..	..	..	..	..	..	..	..
Penmaenmawr	..	*91*	83	82	..	109	106	*119*	162	179	199	200	263
Claughton	..	62	83	90	..	..	..	..	..	199	207	207	..
Giggleswick	26	68	83	93	110	120	133	148	159	187	185	188	..
Ambleside	20	79	91	95	..	..	..	..	..	..	..	..	..
Egremont	41	58	82	92	112	110	114	133	162	176	180	180	294
Cronkbourne	..	..	..	..	..	..	..	..	..	..	..	..	300
Orry's Dale	37	..	*127*	..	..	*136*	136	..	..	..	..	..	301
G.													
Edgeworthstown ..	*73*	..	94	90	..	..	..	..	175	..	..	..	..
Westport	..	..	..	80	..	103	113	..	..	..	..	..	232
Loughbrickland ..	36	59	89	90	..	109	118	165	167	..	..	..	..
Saintfield	..	57	72	87	..	114	128	146	..	..	..	..	298
Antrim	37	64	66	88	97	116	127	157	..	202	..	222	..
Ballymena	..	..	..	..	..	125	131	153	178	..	205	191	..
Londonderry	57	71	86	98	..	112	127	138	171	212	..	..	..
Ballynagard	..	..	48	..	..	..	120	..	..	..	..	202	..
Ramelton	..	..	..	..	..	..	119	153	175	215	..	214	..
H.													
Dalshangan	39	82	..	96	..	..	..	..	..	..	..	..	..
Tynron	35	..	92	93	..	133	145	166	174	215	201	..	..
Thornhill	56	*94*	98	96	..	..	136	..	..	..	..	..	..
Jardington	42	76	85	98	..	124	130	..	171	204	193	..	..
Helensburgh....	42	77	95	105	119	122	132	160	173	..	..	193	249
I.													
Doddington	40	76	87	92	109	116	120	160	167	..	..	..	..
Thirsk	19	38	77	87	105	109	120	154	166	..	181	..	309
East Layton	*64*	72	103	100	..	120	145	*183*	185	196	201	195	315
Durham	48	55	91	*115*	..	136	143	..	185	..	207	..	..

TABLE III.—DATE (DAY OF YEAR) OF FIRST FLOWERING OF PLANTS, 1894—*Continued.*

Station.	Hazel.	Coltsfoot.	Wood Anemone.	Blackthorn.	Garlic Hedge Mustard.	Horse Chestnut.	Hawthorn.	White Ox-eye.	Dog Rose.	Black Knapweed.	Harebell.	Greater Bind-weed.	Ivy.
I.													
Low Fell	50	70	105	104	..	..	141	..	183	220	..	*243*	298
Cambois	49	53	96	97	..	*160*	139	163	171	..	182	201	272
Lilliesleaf	46	..	91	96	..	138	140	163	182	..	187	207	*332*
J.													
Aberdeen	..	82	103	..	..	..	..	173	178	..	..	..	..
K.													
Inverbroom	13	37	106	..	..	..	..	..	178	..	197	..	293

The dates in italics have not been taken into consideration when calculating the means given in Table IV. (p. 123).

Explanation of the dates in the Tables.

1– 31 are in	January.	182–212 are in	July.
32– 59 „	February.	213–243 „	August.
60– 90 „	March.	244–273 „	September.
91–120 „	April.	274–304 „	October.
121–151 „	May.	305–334 „	November.
152–181 „	June.	335–365 „	December.

Scotland. During September and October the record of sunshine was very variable, but November throughout the British Isles proved exceedingly bright.

The corn crops ripened very slowly in the later districts, but the finer weather in September and the early part of October allowed of this lingering harvest being at last brought to an end, at all events in all but the colder parts of Scotland. The yield of both straw and corn was unusually large, but, as stated by Sir John Lawes at the time, " the crops suffered from bad maturing and harvesting." The turnips and other roots made fair growth, and in many places there was an excellent second crop of grass. Indeed, until the end of the season the abundance of keep in the meadows was remarkable. Until the heavy rains set in at the end of October, the ploughing of the land and preparing it for the winter crops proceeded without interruption, but after that time wheat sowing was rendered in many places impracticable, owing to the saturated condition of the ground.

The yield of both wheat and barley, taking the country as a whole, was decidedly above the average, but the most remarkable cereal crop of the year was oats, which yielded the heaviest crop since official statistics were first collected in 1884. The harvest began in most districts from about a fortnight to nearly a month later than in 1893, but at earlier dates than in either 1891 or 1892. Taking the country generally the crop of beans and peas was about an average one. Early potatoes as a rule yielded badly owing to the May frosts; the later varieties were also under the average, and in many places much diseased. Both turnips and mangolds were unusually good crops.

TABLE IV.—MEAN DATES (DAY OF YEAR) FOR THE FIRST FLOWERING OF PLANTS IN 1894, AND THEIR VARIATIONS FROM THE AVERAGE.

Plants.	1894.	Approximate Average.	Variation from Average.	1894.	Approximate Average.	Variation from Average.	1894.	Approximate Average.	Variation from Average.	1894.	Approximate Average.	Variation from Average.
	A. Eng. S.W.			B. Ireland, S.			C. Eng. S.			D. Eng. Mid.		
Hazel	23	23	Av.	14	21	— 7	28	31	— 3	32	35	— 3
Coltsfoot	46	44	+ 2	41	42	— 1	53	52	+ 1	59	56	+ 3
Wood Anemone	78	58	+20	64	56	+ 8	79	66	+13	82	70	+12
Blackthorn	77	91	—14	66	91	—25	86	91	— 5	87	93	— 6
Garlic Hedge Mustard	94	111	—17	101	111	—10	101	111	—10	104	113	— 9
Horse Chestnut	105	126	—21	104	126	—22	111	126	—15	113	128	—15
Hawthorn	111	131	—20	112	131	—19	115	131	—16	116	133	—17
White Ox Eye	137	139	— 2	132	139	— 7	136	139	— 3	143	141	+ 2
Dog Rose	151	156	— 5	155	160	— 5	154	155	— 1	158	158	Av.
Black Knapweed	176	175	+ 1	200	179	+21	174	174	Av.	183	177	+ 6
Harebell	190	189	+ 1	..	193	..	179	188	— 9	192	191	+ 1
Greater Bindweed	188	195	— 7	185	199	—14	194	194	Av.	201	197	+ 4
Ivy	268	263	+ 5	256	266	—10	278	270	+ 8	279	274	+ 5
Mean for the 13 Plants	126	131	— 5	119*	127*	—8*	130	133	— 3	135	136	— 1

Plants.	E. Eng. E.			F. Eng. N.W.			G. Ireland, N.			H. Scotland, W.		
Hazel	27	36	— 9	35	32	+ 3	43	29	+14	43	33	+10
Coltsfoot	49	57	— 8	66	53	+13	63	50	+13	78	54	+24
Wood Anemone	80	71	+ 9	84	67	+17	76	64	+12	93	68	+25
Blackthorn	83	95	—12	90	97	— 7	89	97	— 8	98	99	— 1
Garlic Hedge Mustard	101	115	—14	109	117	— 8	97	117	—20	119	119	Av.
Horse Chestnut	108	130	—22	113	132	—19	113	132	—19	126	134	— 8
Hawthorn	111	135	—24	122	137	—15	123	137	—14	136	139	— 3
White Ox Eye	138	143	— 5	141	145	— 4	152	145	+ 7	163	147	+16
Dog Rose	148	157	— 9	161	161	Av.	173	164	+ 9	173	164	+ 9
Black Knapweed	165	176	—11	185	180	+ 5	210	183	+27	210	183	+27
Harebell	186	190	— 4	193	194	— 1	205	197	+ 8	197	197	Av.
Greater Bindweed	192	196	— 4	194	200	— 6	207	203	+ 4	193	203	—10
Ivy	267	273	— 6	290	271	+19	265	271	— 6	249	273	—24
Mean for the 13 Plants	127	136	— 9	137	137	Av.	140	138	+ 2	144	139	+ 5

Plants.	I. Eng. N.E.			J. Scotland, E.			K. Scotland, N.			British Isles.		
Hazel	42	37	+ 5	..	38	..	13	37	—24	30	31	— 1
Coltsfoot	61	58	+ 3	82	59	+23	37	58	—21	58	53	+ 5
Wood Anemone	93	72	+21	103	73	+30	106	72	+34	85	67	+18
Blackthorn	99	102	— 3	..	103	..	..	110	..	86	95	— 9
Garlic Hedge Mustard	107	122	—15	..	123	..	..	130	..	104	115	—11
Horse Chestnut	124	137	—13	..	138	..	..	145	..	113	130	—17
Hawthorn	135	142	— 7	..	143	..	..	150	..	120	135	—15
White Ox Eye	160	150	+10	173	151	+22	..	158	..	147	144	+ 3
Dog Rose	177	163	+14	178	166	+12	178	173	+ 5	164	162	+ 2
Black Knapweed	208	182	+26	..	185	..	..	192	..	190	179	+11
Harebell	192	196	— 4	..	199	..	197	206	— 9	192	194	— 2
Greater Bindweed	201	202	— 1	..	205	..	..	212	..	195	199	— 4
Ivy	299	274	+25	..	277	..	293	276	+17	274	271	+ 3
Mean for the 13 Plants	146	141	+ 5	..	143	..	..	148	..	135	137	— 2

* For 12 Plants only.

+ indicates the number of days later than the average date.

— " " " earlier " "

Av. " average date.

TABLE V.—DATE (DAY OF YEAR) OF SONG AND MIGRATION OF BIRDS, AND FIRST APPEARANCE OF INSECTS, 1894.

Station.	Song.	Migration.					Insects.				
	Song Thrush First heard.	Swallow First seen.	Cuckoo First heard.	Nightingale First heard.	Flycatcher First seen.	Swallow Last seen.	Honey Bee.	Wasp.	Small White Butterfly.	Orange Tip Butterfly.	Meadow Brown Butterfly.
A.											
Marazion	20	99	93	..	..	289	75	87	79	135	178
Mawnan Smith	..	112	..	..	103	..	75	..	77	121	173
Falmouth	..	113	..	..	..	..	45	103	..	..	..
Tiverton	..	118	103	..	..	..	..	..	..	..	..
Westward Ho	..	82	..	..	133	..	..	..	82	114	..
Instow	..	99	110	..	..	..	..	81	81	..	..
Barnstaple	21	..	..	..	..	..	..	..	..	..	..
Sidcot	..	94	91	126	130	287	..	..	..	115	110
Long Ashton	..	106	98	..	133	..	..	..	..	*152*	..
Clifton	..	..	103	..	..	..	..	..	84	111	176
Penarth	..	..	..	..	..	..	62	98	82	111	169
Cardiff	..	95	103	..	..	270	13	81	87	..	..
Castleton	12	101	96	..	140	284	70	82	101	103	127
Bassaleg	21	117	97	114	..	288	51	89	..	..	..
St. Arvan's	17	94	99	..	129	278	39	88	92	..	178
St. David's	39	107	107	..	..	284	51	..	*124*	..	..
Aberystwith	14	97	108	..	135	..	62	93	93	118	177
B.											
Killarney	14	111	105	..	..	..	..	89	92	103	171
Ferns	..	104	105	..	..	278	..	85	90	107	..
Woodenbridge	..	91	102	..	..	281	..	94	..	95	..
C.											
Bembridge	12	94	96	96	*196*	303	62	79	92	..	187
Whitchurch Canonicorum	1	110	87	110	..	..	69	65	79	..	..
Bere Regis	..	79	82	90	..	..	..	..	..	..	..
Blandford	17	93	90	107	110	..	52	92	78	77	94
Buckhorn Weston	33	104	93	97	105	299	38	87	83	90	174
Pennington	21	96	101	107	..	293	58	83	86	138	180
Strathfield Turgiss	32	98	93	106	123	285	71	83	98	127	173
Bexhill-on-Sea	12	109	90	103	121	306	60	80	93	125	148
Muntham	28	95	92	102	147	286	28	91	91	136	..
Dover	..	113	..	..	..	299	..	..	..	..	..
Farnborough	..	111	102	105	..	..	..	..	..	..	..
Swanley	..	..	98	..	..	..	..	100	91	..	..
Chislehurst	17	109	91	103	127	286	61	87	93	149	..
Coneyhurst	..	101	95	97	121	276	79	101	..	..	..
Churt Vicarage	31	101	96	108	..	283	55	87	97	125	179
Churt	13	92	97	100	124	298	..	..	98	124	126
Cranleigh	38	95	93	102	124	293	35	97	61	108	140
Winterfold	28	97	94	103	122	289	28	85	..	..	..
Oxshott	33	110	99	106	..	..	..	..	..	..	..
Ashtead	..	94	97	101	..	..	55	..	84	119	..
Addlestone	36	105	99	111	102	..	50	34	..	..	..
East Molesey	10	112	107	..	..	*257*	39	62	88	119	..
Marlborough	26	101	101	..	..	..	..	..	84	133	167
Whatley	..	97	97	115	138	277	80	92	90	92	165
Reading	*44*	..	..	..	..	..	..	83	83	..	..
D.											
Oxford	21	103	98	..	..	..	..	..	83	..	..
Cheltenham	15	105	105	*119*	144	285	70	84	91	..	181
Beckford	12	103	97	107	139	293	12	101	86	103	..
Watford	..	102	..	107	*153*	..	..	92	90	..	..
St. Albans (The Grange)	..	..	100	100	..	..	..	75	82	..	..
St. Albans (Add. Lodge)	22	116	112	106	..	..	39	42	84	119	..
St. Albans (Worley Road)	22	105	98	105	138	301	..	..	..	..	..

TABLE V.—DATE (DAY OF YEAR) OF SONG AND MIGRATION OF BIRDS, AND FIRST APPEARANCE OF INSECTS, 1894—*Continued.*

Station.	Song.	Migration.					Insects.				
	Song Thrush First heard.	Swallow First seen.	Cuckoo First heard.	Nightingale First heard.	Flycatcher First seen.	Swallow Last seen.	Honey Bee.	Wasp.	Small White Butterfly.	Orange Tip Butterfly.	Meadow Brown Butterfly.
D.											
Radlett	35	109	97	100	136	..	58	91	..	..	..
Berkhamsted	14	97	98	105	110	296	62	80	80	133	..
Harpenden	..	94	98	106	..	..	..	104	95	92	..
Ross	..	103	107	..	134	286	39	91	..	..	..
Breinton	..	107	98	..	141	284	62	95	85	93	..
Evesham	..	..	..	104	..	269	29	..	..	144	182
Henley-in-Arden	..	107	98	109	..	..	..	..	83	121	..
Northampton	..	..	98	99	..	..	75	..	90	..	..
Churchstoke	41	116	99	..	144	..	65	100	98	103	180
Burbage	12	113	99	..	141	284	35	79	88	*152*	..
Thurcaston	..	98	..	..	..	..	..	..	95	138	..
Uppingham	..	..	*81*	117	*111*	..	..	..	..	..	111
Tean	35	102	106	..	..	280	69	..	90	..	..
Beeston	..	102	106	..	..	277	..	90	87	..	..
Hodsock	36	101	105	119	141	281	21	99	82	111	..
Macclesfield	40	117	105	..	..	276	62	79	101	..	..
Belton	19	105	102	111	140	321	18	91	..	144	..
Harrogate	35	99	105	..	130	324	77	74	100	..	..
E.											
Hatfield	..	114	99	102	..	..	..	..	..	..	..
Hitchin	14	102	101	..	..	..	12	71	87	..	..
Ashwell	..	111	102	107	140	300	..	..	..	..	..
Bocking	..	..	93	..	..	..	..	..	..	..	..
Lexden	21	109	100	107	..	283	33	92	85	108	182
Sproughton	16	110	102	105	133	318	35	85	98	111	..
Tacolneston	..	101	99	..	..	..	..	..	..	118	..
F.											
Ellesmere	..	..	100	..	..	..	..	..	..	115	..
Penmaenmawr	..	112	99	..	..	285	75	82	..	..	..
Claughton	..	113	112	..	..	..	..	..	..	..	..
Giggleswick	36	108	109	..	131	282	..	..	..	..	..
Ambleside	43	105	105	..	..	..	..	..	*118*	118	..
Egremont	15	105	107	..	117	264	30	92	89	117	182
Cronkbourne	..	..	..	..	..	269	..	..	..	..	..
Orry's Dale	36	..	*138*	..	..	..	35	..	..	..	..
Sulby	48	109	119	..	..	283	74	88	108	..	150
G.											
Edgeworthstown	..	105	108	..	..	..	79	..	87	109	..
Westport	..	91	109	..	..	268	..	36	..	..	..
Loughbrickland	41	106	110	..	..	272	38	..	109	118	..
Saintfield	31	98	117	..	..	..	..	..	108	120	..
Antrim	36	105	107	..	143	272	87	143	118	..	..
Ballymena	..	108	116	..	*167*	..	..	109	108	117	182
Londonderry	19	104	119	..	..	..	109	120	108	109	178
Ballynagard	1	105	116	..	..	..	..	..	117	108	..
Ramelton	..	98	101	..	..	263	..	101	..	..	..
H.											
Dalshangan	40	118	109	..	..	..	72	..	98	..	..
Tynron	51	113	109	..	..	261	..	..	111	..	..
Thornhill	..	109	116	..	..	..	67	59	..	..	..
Jardington	35	103	107	..	140	..	..	87	101	..	194
Helensburgh	21	*120*	117	..	..	..	75	112	118	..	..
I.											
Doddington	..	..	98	..	..	..	..	..	..	..	..
Great Cotes	..	111	..	..	135	..	..	..	..	..	..

TABLE V.—DATE (DAY OF YEAR) OF SONG AND MIGRATION OF BIRDS, AND FIRST APPEARANCE OF INSECTS, 1894—*Continued.*

Station.	Song.	Migration.					Insects.				
	Song Thrush First heard.	Swallow First seen.	Cuckoo First heard.	Nightingale First heard.	Flycatcher First seen.	Swallow Last seen.	Honey Bee.	Wasp.	Small White Butterfly.	Orange Tip Butterfly.	Meadow Brown Butterfly.
I.											
Thirsk	..	109	104	..	..	287	32	37	87	150	..
East Layton	35	115	111	..	132	284	57	83	85	145	..
Durham	36	123	113	..	141	..	78	114	110	..	..
Low Fell	45	..	120	..	..	265	..	100	..	..	..
Cambois	..	117	120	..	..	279	83	106	83	..	..
Lilliesleaf	..	118	119	..	136	269	51	121	..	..	..
J.											
Aberdeen	15	122	121	..	130	270	90	142	144	172	..
K.											
Inverbroom	..	..	119	..	176	..	74	87	..	..	..
Mean Dates for the British Isles in 1894	26 Jan. 26	105 April 15	103 April 13	106 April 16	132 May 12	285 Oct. 12	55 Feb. 24	88 March 29	92 April 2	118 April 28	164 June 13
Mean Dates for 1891–3	Feb. 3	April 17	April 23	April 23	May 13	Oct. 14	Feb. 26	April 6	April 11	May 6	June 8

The dates in italics have not been taken into consideration when calculating the means for the British Isles.

The apple blossom suffered so greatly during the frosts of May that the crop of fruit was almost everywhere a failure. The yield of plums was also small, except in the south-western, southern, and eastern counties of England, where it was about average. The pear crop proved a remarkably heavy one in most parts of England, but this was far from being the case in Scotland or Ireland. Mr. G. Bunyard, of Maidstone, a well known authority on fruit culture, attributes the enormous crop of pears in England to the following causes, viz.: The small yield in 1893, the heavy rains of the previous autumn, and the well ripened wood. He accounts for the crop escaping destruction by the May frosts to the early flowering of the trees and the pendent character of the blossoms.

The autumn tints were generally poor, owing to the sunless character of October. Wild berries of all kinds were exceptionally abundant, especially holly berries.

The dates for the ivy are very variable, but in most districts later than the average.

In certain localities the swallow was very late in taking its departure, but, taking the country as a whole, this comes out only three days later than in 1893.

The Year.

Between the third week in March and the third week in May plants came as a rule into blossom in advance of their usual time, and towards the end of

Description of Crop.	A. SW.	C. S.	D. Mid.	E. E.	F. NW.	I. NE.	H. W.	J. E.	K. N.	B. and G. S and N.	British Isles.
Wheat	5°/o O. Av.	6°/o O. Av.	8°/o O. Av.	5°/o O. Av.	9°/o O. Av.	1°/o O. Av.	1°/o O. Av.	3°/o O. Av.	9°/o O. Av.	O. Av.	O. Av.
Barley	6°/o O. Av.	5°/o O. Av.	11°/o O. Av.	6°/o O. Av.	10°/o O. Av.	2°/o O. Av.	3°/o O. Av.	Av.	15°/o O. Av.	O. Av.	O. Av.
Oats	12°/o O. Av.	16°/o O. Av.	13°/o O. Av.	5°/o O. Av.	11°/o O. Av.	4°/o O. Av.	6°/o O. Av.	5°/o U. Av.	16°/o O. Av.	O. Av.	Much O. Av.
Corn Harvest began, average Date	225 (Aug. 13)	218 (Aug. 6)	224 (Aug. 12)	218 (Aug. 6)	228 (Aug. 16)	233 (Aug. 21)	249 (Sept. 6)	242 (Aug. 30)	246 (Sept. 3)	239 (Aug. 27)	232 (Aug. 20)
Beans	Av.	Av.	U. Av.	O. Av.	Av.	O. Av.	Av.	O. Av.	..	O. Av.	O. Av.
Peas	Av.	O. Av.	Av.	U. Av.	Av.	O. Av.	..	Av.	..	O. Av.	Av.
Potatoes	U. Av.	U. Av.	Av.	Av.	Av.	U. Av.	U. Av.	Av.	O. Av.	Av.	U. Av.
Turnips	Av.	O. Av.	O. Av.	O. Av.	Av.	U. Av.	O. Av.	Av.	Av.	Av.	O. Av.
Mangolds	O. Av.	O. Av.	Av.	O. Av.	Av.	Av.	Av.	Av.	..	Av.	O. Av.
Hay (Permanent Pastures)	26°/o U. Av.	37°/o O. Av.	23°/o O. Av.	14°/o O. Av.	19°/o O. Av.	8°/o O. Av.	8°/o O. Av.	10°/o O. Av.	9°/o O. Av.	Much O. Av.	Much O. Av.
Hay (Clover, &c.)	22°/o O. Av.	22°/o O. Av.	11°/o O. Av.	2°/o O. Av.	15°/o O. Av.	14°/o O. Av.	9°/o O. Av.	18°/o O. Av.	15°/o O. Av.	Much O. Av.	Much O. Av.

The variations from the average (1885-94) relating to Wheat, Barley, Oats and Hay have been obtained from the *Agricultural Produce Statistics* issued by the Board of Agriculture, but those for the other crops from Returns which appeared in the *Agricultural Gazette*.

TABLE VII.—ESTIMATED YIELD OF FRUIT CROPS IN 1894.

Description of Crop.	England.						Scotland.	Ireland.	British Isles.
	A. SW.	C. S.	D. Mid.	E. E.	F. NW.	I. NE.	H. J. and K. W. E. and N.	B. and G. S. & N.	
Apples	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	Much U. Av.
Pears	O. Av.	O. Av.	O. Av.	O. Av.	Av.	U. Av.	U. Av.	U. Av.	O. Av.
Plums	Av.	Av.	U. Av.	Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.
Raspberries	Av.	Av.	U. Av.	Av.	Av.	U. Av.	Av.	Av.	Av.
Currants	Av.	Av.	U. Av.	Av.	Av.	U. Av.	Av.	Av.	Av.
Gooseberries	Av.	Av.	U. Av.	Av.	Av.	U. Av.	Av.	Av.	Av.
Strawberries	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	Much U. Av.

Symbols:—O. = Over. U. = Under. Av. = Average. This Table has been compiled from Returns which appeared in the *Gardeners' Chronicle*.

TABLE VIII.

APPROXIMATE VARIATIONS FROM THE AVERAGE IN MEAN TEMPERATURE, RAINFALL, AND SUNSHINE, 1893–94.

Winter 1893–94.

Months.	Eng. SW.	Ire. S.	Eng. S.	Eng. Mid.	Eng. E.	Eng. NW.	Ire. N.	Scot. W.	Eng. N.E.	Scot. E.	Scot. N.
Temperature.											
	°	°	°	°	°	°	°	°	°	°	°
December	+2·3	+2·5	+1·8	+3·0	+2·0	+3·3	+2·5	+4·0	+3·3	+4·0	+3·5
January	—0·8	—1·6	—0·4	—2·0	—0·4	0·0	—1·0	0·0	—0·6	—0·4	—0·4
February	+1·0	+1·5	+1·0	+0·8	+0·8	+1·3	+1·3	+1·3	+0·3	+0·3	—0·3
Winter ...	+0·8	+0·8	+0·8	+0·6	+0·8	+1·5	+0·9	+1·8	+1·0	+1·3	+0·9
Rain.											
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
December	+0·5	+1·5	+0·2	+0·3	—0·5	+0·5	+0·7	+1·3	—0·8	—0·1	+2·7
January	—0·1	+1·0	+0·2	—0·6	—0·3	+0·1	+1·9	+0·6	—0·4	+0·7	+2·4
February	+0·3	—0·1	—0·1	+0·5	—0·5	+1·9	+1·9	+4·1	+1·2	+3·1	+4·0
Winter	+0·7	+2·4	+0·3	+0·2	—1·3	+2·5	+4·5	+6·0	0·0	+3·7	+9·1
Sunshine.											
	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
December	+ 7	+ 2	+12	+ 5	+14	— 5	+ 5	— 7	— 1	—10	—17
January	+18	0	+23	+16	+17	+18	+ 4	+ 5	+11	— 9	— 2
February	+11	+ 5	+27	+24	+36	— 1	+ 4	— 3	+20	+28	— 6
Winter	+36	+ 7	+62	+45	+67	+12	+13	— 5	+30	+ 9	—25

Spring 1894.

Months.	Eng. SW.	Ire. S.	Eng. S.	Eng. Mid.	Eng. E.	Eng. NW.	Ire. N.	Scot. W.	Eng. N.E.	Scot. E.	Scot. N.
Temperature.											
	°	°	°	°	°	°	°	°	°	°	°
March	+2·0	+1·8	+2·8	+2·0	+2·3	+3·3	+2·3	+3·0	+2·3	+2·5	+2·8
April	+3·3	+2·5	+4·3	+3·5	+3·0	+3·5	+3·0	+3·5	+2·5	+2·5	+3·8
May	—1·6	—1·6	—1·6	—2·8	—2·0	—2·6	—2·8	—2·4	—2·2	—2·4	—2·2
Spring	+1·2	+0·9	+1·8	+0·9	+1·1	+1·4	+0·8	+1·4	+0·9	+0·9	+1·5
Rain.											
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
March	—0·3	—0·4	—0·7	—0·5	—0·6	0·0	—0·2	—0·2	—0·9	—0·6	+1·0
April	—0·1	+1·8	0·0	0·0	+0·2	—0·2	+0·6	—0·6	—0·7	—0·7	—1·9
May	+0·4	+0·2	+0·1	—0·4	+0·5	+0·8	+0·2	+0·3	+1·0	+1·0	+0·3
Spring	0·0	+1·6	—0·6	—0·9	+0·1	+0·6	+0·6	—0·5	—0·6	—0·3	—0·6
Sunshine.											
	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
March	+57	+ 41	+ 57	+ 59	+ 58	+ 68	+ 64	+ 64	+ 78	+ 72	+ 39
April	+18	— 24	+ 9	+ 19	— 4	+ 14	— 21	— 16	+ 16	— 13	+ 19
May	— 9	— 14	— 21	— 23	— 33	— 18	— 11	— 6	— 8	+ 14	+ 45
Spring	+66	+ 3	+ 45	+ 55	+ 21	+ 64	+ 32	+ 42	+ 86	+ 73	+103

+ indicates above the average, — below it.

TABLE VIII.

VARIATIONS FROM THE AVERAGE—*Continued.*

Summer 1894.

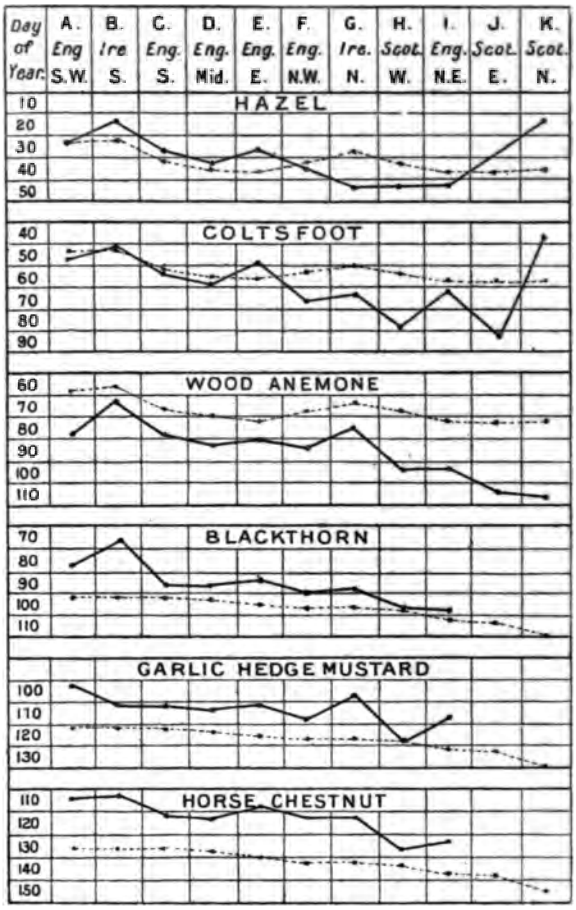
Months.	Eng. SW.	Ire. S.	Eng. S.	Eng. Mid.	Eng. E.	Eng. NW.	Ire. N.	Scot. W.	Eng. NE.	Scot. E.	Scot. N.
Temperature.											
	°	°	°	°	°	°	°	°	°	°	°
June	—0·8	0·0	—0·5	—0·5	—0·8	—1·0	—0·8	—0·8	—1·0	—1·0	+0·3
July	—0·8	—0·5	—0·3	—0·3	—0·3	+0·5	+0·3	+0·5	+1·0	+0·8	+2·3
August	—1·0	—1·2	—0·8	—1·2	—1·4	—1·2	—0·8	—0·8	—1·2	—0·6	+0·4
Summer ..	—0·9	—0·6	—0·5	—0·7	—0·8	—0·6	—0·4	—0·4	—0·4	—0·3	+1·0
Rain.											
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
June	—0·1	—0·2	0·0	—0·3	+0·4	0·0	0·0	+0·1	+1·1	—0·2	—0·6
July	+1·2	+1·2	+1·8	0·0	+0·6	—0·1	+0·7	—0·6	0·0	+0·9	+1·5
August	+0·2	+0·1	+0·4	—0·3	—0·3	+0·6	—1·0	—0·4	—0·3	+1·1	+1·0
Summer ..	+1·3	+1·1	+2·2	—0·6	+0·7	+0·5	—0·3	—0·9	+0·8	+1·8	+1.9
Sunshine.											
	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
June	— 37	—21	—16	—17	—37	— 9	—16	— 18	—17	—22	+22
July	— 27	—17	—11	0	—14	+ 5	+ 7	+ 7	+30	—17	+28
August	— 53	—75	—50	—50	—30	—53	—27	—15	—26	— 8	+ 7
Summer ..	—117	—113	—77	—67	—81	—57	—36	—26	—13	—47	+57

Autumn 1894.

Months.	Eng. SW.	Ire. S.	Eng. S.	Eng. Mid.	Eng. E.	Eng. NW.	Ire. N.	Scot. W.	Eng. NE.	Scot. E.	Scot. N.
Temperature.											
	°	°	°	°	°	°	°	°	°	°	°
September ..	— 1·5	— 2·0	— 2·0	—2·3	—2·5	—1·8	—1·3	—1·8	—1·8	—1·3	—0·8
October......	+ 1·2	+ 1·0	+ 1·8	+1·2	+1·4	+0·6	+1·0	—0·4	0·0	—0·6	0·0
November....	+ 1·8	+ 0·8	+ 2·8	+2·5	+2·3	+3·0	+1·5	+3·8	+2·5	+2·8	+3·8
Autumn ..	+0·5	—0.1	+0·9	+0·5	+0·4	+0·6	+0·4	+0·5	+0·2	+0·3	+1·0
Rain.											
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
September ..	—1·4	—2·3	—0·3	—1·1	—0·4	—2·9	—3·0	—4·0	—1·3	—2·2	—3·9
October......	+1·0	+1·6	+1·3	+0·3	—0·2	+0·5	+0·2	—0·6	+1·3	—0·1	—2·8
November....	+2·3	+1·0	+1·1	+0·7	+0·5	—0·7	—0·6	+0·3	—1·4	—1·6	+0·1
Autumn ..	+1·9	+0·3	+2·1	—0·1	—0·1	—3·1	—3·4	—4·3	—1·4	—3·9	—6·6
Sunshine.											
	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
September....	+10	+27	—30	—14	—23	+23	+37	+34	+ 5	+ 7	—22
October......	—10	— 5	—41	—34	—33	+ 3	+12	—14	—30	+ 1	—15
November....	+12	+14	+31	+16	+18	+ 4	+13	+ 7	+10	+23	0
Autumn....	+12	+36	—40	—32	—38	+30	+62	+27	—15	+31	—37

The above Table has been compiled from the variations from the mean given in the *Weekly Weather Reports* issued by the Meteorological Office.

April the dates of first flowering differed but little from those recorded at the same period in the remarkably forward spring of 1893. The cuckoo made its appearance exceptionally early, even earlier than in the previous year—in many places from a week to a fortnight earlier. The year 1894 was a very productive one. Both the hay and corn crops proved unusually heavy, but



1894 ——— Average..........

FIG. 2.—Mean Dates (Day of Year) of Flowering of the Plants in 1894, and also the Average Dates.

much of the latter was harvested under very trying conditions as regards weather. The frosts of May 21st and 22nd entirely destroyed the previous prospect of a glorious fruit season. Indeed, the only really good crop was that of pears, which throughout nearly the whole of England were very abundant.

Observers' Notes.

DECEMBER 1893.—*Mawnan Smith* (A.). 2nd. Dahlias killed. 29th. First hazel catkins out in sheltered valley. Falmouth (A.). During this month 43

different sorts of wild flowers were gathered within a radius of 5 miles. *Tiverton* (A.). 22nd. Violets and a hepatica in flower in garden. *Bassaleg* (A.). I never remember fruit trees with such well ripened wood or having a better promise of bearing in the succeeding year. *Blandford* (C.). 13th. Black guillemot were picked up near here in an exhausted state after the blizzard of the previous day. *Pennington* (C.). 30th. Winter aconite in flower. *Burbage*

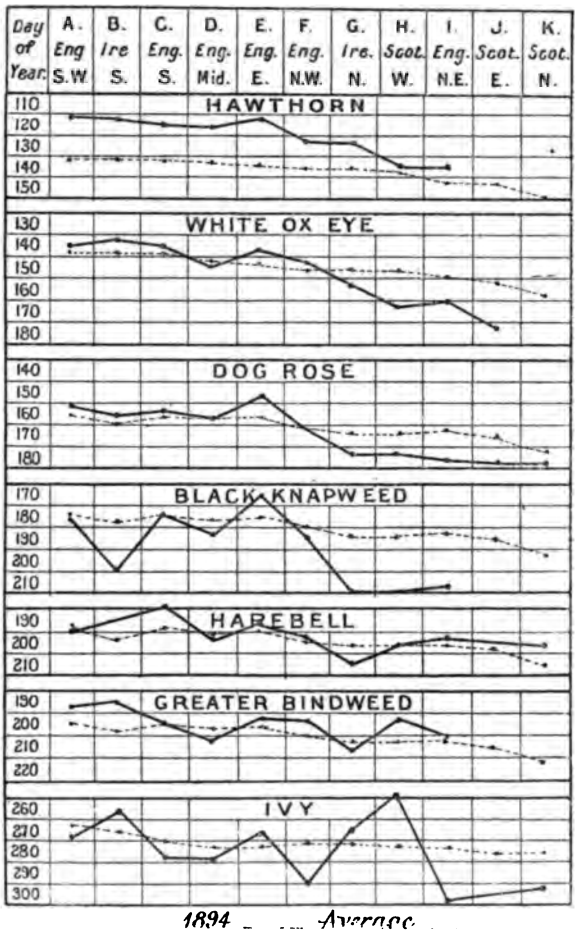


FIG. 3.—Mean Dates (Days of Year) of Flowering of the Plants in 1894, also the Average Dates.

(D.). Holly berries comparatively scarce. *Loughbrickland* (G.). All the hollies in this district shed their leaves at the end of November. This I attribute to the previous dry summer. *Saintfield* (G.). 15th. Gorse in flower as if it were March.

JANUARY 1894.—*Mawnan Smith* (A.). 26th. Wild primrose in blossom. *Falmouth* (A.). 5th. Camellias in bloom in the open air. *Sidcot* (A.). During the first week flowers came out in quick succession. *Aberystwith* (A.). 29th. Frog spawn first seen. *Bembridge* (C.). 2nd-4th. Piercing North-east winds which penetrated houses and stores which had never been reached by frost before, and destroyed seed potatoes and dahlia roots. *Addlestone* (C).

28th. Winter aconite in flower. *Berkhamsted* (D.). 17th. Winter aconite in flower, earliest since 1890. *Evesham* (D.). 24th. Hazel catkins out. *Burbage* (D.). 13th. Winter aconite in flower. *Tean* (D.). Primroses found in flower, a very uncommon thing here in January. Hazel catkins exceptionally fine. *Hodsock* (D.). 13th. Winter aconite in flower. *Harrogate* (D.). 6th. The exposed thermometer fell to —8°·7. Berberis Darwinii, Aucuba Japonica, and Ulex Europæus were killed outright. *Hitchin* (E.). 2nd. Hazel catkins out. *Tacolneston* (E.). 19th. Hazel catkins very abundant. *Antrim* (G.). 6th. Evergreens suffered greatly from severe frost, Portuguese laurels became entirely brown. *Dalshangan* (H.). 1st. Winter aconite in flower. *Lilliesleaf* (I.). 5th. Winter aconite in flower. *Aberdeen* (J.). 6th. The severest frost since 881. Shrubs suffered severely, but not low growing vegetation, which was overed with 4 ins. of snow.

FEBRUARY.—*Barnstaple* (A.). 28th. Vegetation singularly forward, the average number of species of wild flowers recorded by me for the previous 20 years is 16 for the end of February; in 1893, 27 were recorded; and in 1894, 35. *Bembridge* (C.). 21st. Picked a dish of mushrooms from a bank out of doors. *Whitchurch Canonicorum* (C.). 14th. In the village children's wild flower class 30 different species of wild flowers were registered. *Pennington* (C.). Winter migrants very scarce. *Burbage* (D.). 22nd. Rooks began building. *Harrogate* (D.). 25th. Frog spawn first seen. *Tynron* (H.). 23rd. Curlew first seen. *Durham* (I.). Woodcock and snipe very scarce, especially the former.

MARCH.—*Aberystwith* (A.). 26th. About 26 wild flowers out, only half that number in 1893. *Bembridge* (C.). 31st. Cut asparagus out of doors. Vegetation very forward. *Pennington* (C.). Queen wasps plentiful. *Whitchurch* (C.). 21st. Queen wasps found together in a crevice of garden wall coping. *Tean* (D.). 10th. Primroses as abundant as they are usually at the beginning of April. *Hitchin* (E.). Queen wasps last winter hibernated together in great numbers, as many as filled an old teapot were found under a tarpaulin on an outhouse roof.

APRIL.—*Tiverton* (A.). 20th. Hawthorn out on five different bushes (specimens received). *Westward Ho* (A.). Queen wasps numerous. *St. Arvans* (A.). 11th. Hailstones as large as nuts, which cut off fruit and slit rose and other leaves. *Killarney* (B.). 26th. Corncrake first heard. *Woodenbridge* (B.). 17th. Corncrake first heard. *Bembridge* (C.). 18th. Gloire de-Dijon rose in flower on wall of house. *Pennington* (C.). 26th. Swift first seen. *Strathfield Turgiss* (C.). 22nd. Hawthorn extraordinarily full of blossom, and trees perfectly white. *Churt* (C.). Took between 70 and 80 wasps early in the month. Ladybirds abundant. *Berkhamsted* (D.). 2nd. Wild cherry in flower. *Burbage* (D.). 30th. Landrail first heard. *Beeston* (D.). 28th. Corncrake first heard. *Lexden* (E.). 29th. Swift first seen. *Settle* (F.). The collector of plovers' eggs for market said he had never known them so early. *Sulby* (F.). 27th. Corncrake first heard. *Edgeworthstown* (G.). 18th. Corncrake first heard. *Loughbrickland* (G.). 23rd. Corncrake first heard. *Thirsk* (I.). 18th. Apricots as large as cherries. *East Layton* (I.). 22nd. Never recollect seeing blackthorn so laden with blossom. *Inverbroom* (K.). 16th. Pear blossom over and fruit set.

MAY.—*Mawnan Smith* (A.). A great many queen wasps this spring. Hawthorn remarkably full of blossom. 17th. Swift first seen. *Barnstaple* (A.). The past 12 years' average for the number of wild flowers observed by me in blossom at the end of May is 170. Number observed in 1893—240, in 1894—227. *Long Ashton* (A.). More cuckoos and swallows than I remember here for 18 years. *Penarth* (A.). 21st. Frost blackened many potatoes about Penarth and Cardiff. Spring butterflies scarce. *Bassaleg* (A.). The frost of 21st and continuous East wind and cold nights have injured strawberries and apples more than I ever remember before. *St. Arvans* (A.). 31st. Hawthorn blossom especially abundant, every bush and hedge being as white as snow. *Killarney* (B.). 20th-22nd. The severest frost since May 1864. Even briar, ivy and ash shoots much injured. *Woodenbridge* (B.). Frosts on 21st, 22nd and 23rd, which blackened potatoes, beans, &c., and caused gooseberries to fall from the trees. *Bembridge* (C.). 20th and 21st. No injuries by frost here although exposed to the north-east. *Buckhorn Weston* (C.). 20th. Sharp frost,

which cut back potatoes, damaged fruit blossom, and caused gooseberries to drop off. *Twyford* (C.). Although on high ground, the frost of 20th destroyed at least 10,000 young rose blooms and 200 newly planted dahlias. *Strathfield Turgiss* (C.). A very forward spring up to the 21st, when a very keen frost literally cut everything to pieces—laurels, ash trees and horsechestnuts suffered severely. Cuckoos very abundant, nightingales comparatively scarce. *Farnborough* (C.). The frost of the 19th cut off buds of the dog rose ready to open and almost entirely destroyed strawberry crop. *Chislehurst* (C.). All flowering shrubs exceedingly full of blossom, especially hawthorn. *Coneyhurst* (C.). Hawthorn more thickly flowered than for some years. *Churt Vicarage* (C.). A very great number of queen wasps till after frost in third week. The frosts of 20th and 21st, and the succeeding cold weather, have done more harm than I ever remember. The young foliage and shoots of trees and hedges are blackened as if by fire. *Churt* (C.). Chestnut growths of underwood especially presented a black and scorched appearance after frosts of 20th and 21st. Butterflies scarce. *Cranleigh* (C.). The frost of 21st, followed by a bright sun in the early morning, did much damage, especially among the potatoes. *Winterfold* (C.). The frosts of 20th and 21st, with hail and snow on both days, injured underwood and fruit blossoms, and cut bracken to the ground. *Oxshott* (C.). The frost did not do much harm here, but was severe in the low ground in the neighbourhood. *Marlborough* (C.). Frosts of the 20th and 21st cut back vegetation severely. *Oxford* (D.). The blossom on chestnut, lilac, laburnum and lime particularly fine. *Beckford* (D.). Potatoes and kidney beans practically killed by frost of 21st, while fruit trees and strawberries suffered severely. The damage sustained was all on the low lying lands, on the high ground over 100 ft. above the brook there was no frost. *St. Albans* (*The Grange*) (D.). 22nd. Sharp ground frost, which did much damage to fruit blossom and vegetation generally. *Radlett* (D.). 18th. First swarm of bees. *Harpenden* (D.). The frosts at end of third week almost entirely destroyed apple blossom. Gooseberry bushes almost bared of their fruit. Potatoes so injured that they never recovered, and yielded minute tubers only. *Ross* (D.). 14th. Corncrake first heard. *Breinton* (D.). Frosts of 19th, 20th, and 21st cut oaks, ashes, nettles, &c. *Burbage* (D.). Hawthorn blossom very plentiful. *Thurcaston* (D.). Enormous show of bloom of all kinds. The frosts have not done much harm here. *Tean* (D.). 24th. Young oak and ash leaves blackened, and potatoes killed by the frost. *Hodsock* (D.). 21st. Potatoes blackened, strawberry blossom destroyed, and young shoots of ivy, oaks, and ash touched. *Macclesfield* (D.). 1st. Sycamores and hawthorn in full leaf and bloom. Fruit blossom very abundant. Blossom on fruit trees and strawberries destroyed by frost towards the end of the month. Laburnums nearly stripped of bloom, ash bloom and leaves all killed, young shoots of sycamore, alder, poplar, and hawthorn also killed. *Belton* (D.). 20th and 21st. Everything being wet, great damage was done by the frost. Some oaks completely blackened, others partially so, according to position. Ash trees blackened and appear as if dead. *Hitchin* (E.). 20th and 21st. Potatoes and beans cut off by frost. Oak, ash, elms, beech, maple, elder, plums, gooseberries, currants, strawberries, thistles, plantains, and ivy frostbitten. *Ashwell* (E.). 10th. Swift first seen. 21st and 22nd. Sharp frosts: geraniums, dahlias, &c. cut down. *Sproughton* (E.). 21st. The disastrous frost experienced in many parts of the country was here modified by a slight snow shower between 4 and 5 a.m., which probably was of great service to vegetation. *Tacolneston* (E.). 21st. Potatoes killed to the ground in exposed places by frost. *Ellesmere* (F.). 20th. Young shoots of oak, ash, ivy, hawthorn, &c. killed by frost. *Penmaenmawr* (F.). Fruit blossom not quite as abundant as in 1893, but hawthorn very full of bloom. 25th. Much damage done to young potatoes by frost. *Claughton* (F.). 20th, 21st, and 22nd. Potatoes and dahlias cut by frost. *Giggleswick* (F.). 21st and 22nd. Great damage to trees, potatoes, &c. by frost. An ash tree just showing leaves on May 1st was scarcely in full leaf by June 1st. *Ambleside* (F.). 20th-22nd. Young growths on beech, oak, and spruce, which were very forward, destroyed by frost. *Egremont* (F.). 20th and 21st. Great damage done to potatoes and vegetation in general by frost. *Loughbrickland* (G.). 20th and 21st. Potatoes cut to the ground, and the new growths of oak, ash, sycamore, silver fir, box, and bay laurel killed by frost. *Antrim* (G.). 20th and 21st. Potatoes cut to the ground by frost and young shoots of the ivy,

TABLE V.—DATE (DAY OF YEAR) OF SONG AND MIGRATION OF BIRDS, AND FIRST APPEARANCE OF INSECTS, 1894.

Station.	Song.	Migration.					Insects.				
	Song Thrush First heard.	Swallow First seen.	Cuckoo First heard.	Nightingale First heard.	Flycatcher First seen.	Swallow Last seen.	Honey Bee.	Wasp.	Small White Butterfly.	Orange Tip Butterfly.	Meadow Brown Butterfly.
A.											
Marazion	20	99	93	..	..	289	75	87	79	135	178
Mawnan Smith	..	112	..	..	103	..	75	..	77	121	173
Falmouth	..	113	..	..	..	..	45	103	..	..	..
Tiverton	..	118	103	..	..	..	..	..	..	..	..
Westward Ho	..	82	..	..	133	..	..	..	82	114	..
Instow	..	99	110	..	..	..	..	81	81	..	..
Barnstaple	21	..	..	..	..	..	..	..	..	..	..
Sidcot	..	94	91	126	130	287	..	..	..	115	110
Long Ashton	..	106	98	..	133	..	..	..	..	*152*	..
Clifton	..	..	103	..	..	..	..	..	84	111	176
Penarth	..	..	..	..	..	..	62	98	82	111	169
Cardiff	..	95	103	..	..	270	13	81	87	..	..
Castleton	12	101	96	..	140	284	70	82	101	103	127
Bassaleg	21	117	97	114	..	288	51	89	..	..	..
St. Arvan's	17	94	99	..	129	278	39	88	92	..	178
St. David's	39	107	107	..	..	284	51	..	*124*	..	..
Aberystwith	14	97	108	..	135	..	62	93	93	118	177
B.											
Killarney	14	111	105	..	..	..	..	89	92	103	171
Ferns	..	104	105	..	..	278	..	85	90	107	..
Woodenbridge	..	91	102	..	..	281	..	94	..	95	..
C.											
Bembridge	12	94	96	96	*196*	303	62	79	92	..	187
Whitchurch Canonicorum	1	110	87	110	..	..	69	65	79	..	..
Bere Regis	..	79	82	90	..	..	..	..	..	..	..
Blandford	17	93	90	107	110	..	52	92	78	77	94
Buckhorn Weston	33	104	93	97	105	299	38	87	83	90	174
Pennington	21	96	101	107	..	293	58	83	86	138	180
Strathfield Turgiss	32	98	93	106	123	285	71	83	98	127	173
Bexhill-on-Sea	12	109	90	103	121	306	60	80	93	125	148
Muntham	28	95	92	102	147	286	28	91	91	136	..
Dover	..	113	..	..	..	299	..	..	..	..	..
Farnborough	..	111	102	105	..	..	..	..	..	..	..
Swanley	..	..	98	..	..	..	..	100	91	..	..
Chislehurst	17	109	91	103	127	286	61	87	93	149	..
Coneyhurst	..	101	95	97	121	276	79	101	..	..	..
Churt Vicarage	31	101	96	108	..	283	55	87	97	125	179
Churt	13	92	97	100	124	298	..	..	98	124	126
Cranleigh	38	95	93	102	124	293	35	97	61	108	140
Winterfold	28	97	94	103	122	289	28	85	..	..	..
Oxshott	33	110	99	106	..	..	..	..	..	..	..
Ashtead	..	94	97	101	..	..	55	..	84	119	..
Addlestone	36	105	99	111	102	..	50	34	..	..	..
East Molesey	10	112	107	..	..	*257*	39	62	88	119	..
Marlborough	26	101	101	..	..	..	..	..	84	133	167
Whatley	..	97	97	115	138	277	80	92	90	92	165
Reading	*44*	..	..	..	..	..	..	83	83	..	..
D.											
Oxford	21	103	98	..	..	..	..	..	83	..	..
Cheltenham	15	105	105	*119*	144	285	70	84	91	..	181
Beckford	12	103	97	107	139	293	12	101	86	103	..
Watford	..	102	..	107	*153*	..	..	92	90	..	..
St. Albans (The Grange)	..	..	100	100	..	..	..	75	82	..	..
St. Albans (Add. Lodge)	22	116	112	106	..	..	39	42	84	119	..
St. Albans (Worley Road)	22	105	98	105	138	301	..	..	..	..	..

TABLE V.—DATE (DAY OF YEAR) OF SONG AND MIGRATION OF BIRDS, AND FIRST APPEARANCE OF INSECTS, 1894—*Continued.*

Station.	Song.	Migration.					Insects.				
	Song Thrush First heard.	Swallow First seen.	Cuckoo First heard.	Nightingale First heard.	Flycatcher First seen.	Swallow Last seen.	Honey Bee.	Wasp.	Small White Butterfly.	Orange Tip Butterfly.	Meadow Brown Butterfly.
D.											
Radlett	35	109	97	100	136	..	58	91	..	..	..
Berkhamsted	14	97	98	105	110	296	62	80	80	133	..
Harpenden	..	94	98	106	..	..	..	104	95	92	..
Ross	..	103	107	..	134	286	39	91	..	..	..
Breinton	..	107	98	..	141	284	62	95	85	93	..
Evesham	..	..	..	104	..	269	29	..	..	144	182
Henley-in-Arden	..	107	98	109	..	..	..	..	83	121	..
Northampton	..	..	98	99	..	..	75	..	90	..	..
Churchstoke	41	116	99	..	144	..	65	100	98	103	180
Burbage	12	113	99	..	141	284	35	79	88	*152*	..
Thurcaston	..	98	..	..	..	..	..	..	95	138	..
Uppingham	..	..	*81*	117	*111*	..	..	..	..	..	111
Tean	35	102	106	..	..	280	69	..	90	..	..
Beeston	..	102	106	..	..	277	..	90	87	..	..
Hodsock	36	101	105	119	141	281	21	99	82	111	..
Macclesfield	40	117	105	..	..	276	62	79	101	..	..
Belton	19	105	102	111	140	321	18	91	..	144	..
Harrogate	35	99	105	..	130	324	77	74	100	..	..
E.											
Hatfield	..	114	99	102	..	..	..	..	..	..	..
Hitchin	14	102	101	..	..	..	12	71	87	..	..
Ashwell	..	111	102	107	140	300	..	..	..	..	..
Bocking	..	..	93	..	..	..	..	..	..	..	..
Lexden	21	109	100	107	..	283	33	92	85	108	182
Sproughton	16	110	102	105	133	318	35	85	98	111	..
Tacolneston	..	101	99	..	..	..	..	..	..	118	..
F.											
Ellesmere	..	..	100	..	..	..	..	..	.	115	..
Penmaenmawr	..	112	99	..	..	285	75	82	..	..	..
Claughton	..	113	112	..	..	..	..	..	..	..	..
Giggleswick	36	108	109	..	131	282	..	..	..	..	..
Ambleside	43	105	105	..	..	..	..	..	*118*	118	..
Egremont	15	105	107	..	117	264	30	92	89	117	182
Cronkbourne	..	..	..	..	..	269	..	..	..	..	..
Orry's Dale	36	..	*138*	..	..	..	35	..	..	..	..
Sulby	48	109	119	..	..	283	74	88	108	..	150
G.											
Edgeworthstown	..	105	108	..	..	..	79	..	87	109	..
Westport	..	91	109	..	..	268	..	36	..	..	..
Loughbrickland	41	106	110	..	..	272	38	..	109	118	..
Saintfield	31	98	117	..	..	..	..	..	108	120	..
Antrim	36	105	107	..	143	272	87	143	118	..	..
Ballymena	..	108	116	..	*167*	..	..	109	108	117	182
Londonderry	19	104	119	..	..	..	109	120	108	109	178
Ballynagard	1	105	116	..	..	..	..	..	117	108	..
Ramelton	..	98	101	..	..	263	..	101	..	..	..
H.											
Dalshangan	40	118	109	..	..	..	72	..	98	..	..
Tynron	51	113	109	..	..	261	..	..	111	..	..
Thornhill	..	109	116	..	..	..	67	59	.	..	..
Jardington	35	103	107	..	140	..	..	87	101	..	194
Helensburgh	21	*120*	117	..	..	..	75	112	118	..	..
I.											
Doddington	..	..	98	..	..	..	..	..	..	..	..
Great Cotes	..	111	..	..	135	..	..	..	..	..	..

while those which experienced the full power of the sunlight without any previous interval of shadow had been killed. One grower stated that if the plants could have been watered probably little damage would have been done.

Dr. A. BUCHAN inquired whether Mr. Mawley had been able to ascertain if the damage by frost was in any way dependent on the nature of the soil, as it appeared probable that plants on cold soils, such as clay, would be more likely to suffer than those grown on warmer soils.

Mr. E. MAWLEY, in reply, said that for the purpose of preparing averages he would much like to have from 15 to 20 observers in each district, but the actual number of observers was in many districts considerably fewer than that number. The results clearly showed that the best represented districts gave the best results, while those which are imperfectly represented caused the curve to become irregular. As regards the injury to fruit trees from cold or wet, the most critical period in their blossoming was when the flowers were fully expanded, but not yet fertilised. Therefore the nature of the soil, whether warm or cold, might in some cases account for certain fruit trees being affected, while others escaped injury, from the May frosts although growing in the same locality. It was generally understood that the migration of birds to the British Isles was only to a certain extent controlled by the weather here, being principally regulated by their supply of food and the weather prevailing in the countries from which they come. The injurious effect of sunshine upon frost-bitten plants was well known to horticulturists, and he had himself once saved a number of crysanthemums by placing them in the shade before the sun had acquired sufficient power to hurt them. An enthusiastic rosarian with whom he was acquainted, on one occasion, fearing a spring frost would injure his roses, turned the garden hose upon them early in the morning, and so saved his plants, while the foliage of other roses in the same district were greatly damaged.

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

January 16th, 1895.

Ordinary Meeting.

RICHARD INWARDS, F.R.A.S., President, in the Chair.

DUNCAN J. CADDY, M.D., F.R.G.S., 4 Earl's Court Gardens, S.W.;
ENOCH GEORGE MAWBEY, Assoc.M.Inst.C.E., The Firs, Westleigh, Leicester;
EDWARD PRITCHARD, M.Inst.C.E., 37 Waterloo Street, Birmingham;
HENRY THOMAS SQUIRRELL, 5 Station Road, Bexhill-on-Sea; and
WALTER THOMAS, Assoc.M.Inst.C.E., Dover,
were balloted for and duly elected Fellows of the Society.

The following communication was read:—

"THE GALE OF DECEMBER 21ST-22ND, 1894, OVER THE BRITISH ISLES." By CHARLES HARDING, F.R.Met.Soc. (p. 92.)

January 16th, 1895.

Annual General Meeting.

RICHARD INWARDS, F.R.A.S., President, in the Chair.

MR. F. J. BRODIE and MR. M. JACKSON were appointed scrutineers of the ballot for Officers and Council.

MR. F. C. BAYARD read the Report of the Council and the Balance Sheet for 1894 (p. 62).

It was proposed by the PRESIDENT, seconded by MR. F. C. BAYARD, and resolved:—"That the Report of the Council be received and adopted, and printed in the *Quarterly Journal.*"

It was proposed by PROF. J. K. LAUGHTON, seconded by MR. W. M. BEAUFORT, and resolved :—"That the thanks of the Society be given to the Officers and other Members of the Council for their services during the past year."

It was proposed by MR. A. BREWIN, seconded by MR. H. S. EATON, and resolved :—"That the thanks of the Society be given to the Standing Committees and to the Auditors, and that the Committees be requested to continue their duties till the next Council Meeting."

It was proposed by DR. C. T. WILLIAMS, seconded by ADMIRAL J. P. MACLEAR, and resolved :—"That the best thanks of the Royal Meteorological Society be communicated to the President and Council of the Institution of Civil Engineers for having granted the Society free permission to hold its Meetings in the rooms of the Institution."

The PRESIDENT then delivered an Address on "Weather Fallacies" (p. 49).

It was proposed by MR. R. H. SCOTT, seconded by DR. H. R. MILL, and resolved :—"That the thanks of the Society be given to MR. RICHARD INWARDS for his services as President during the past year, and for his Address, and that he be requested to allow it to be printed in the *Quarterly Journal.*"

The scrutineers declared the following gentlemen to be the Officers and Council for the ensuing year :—

President.

RICHARD INWARDS, F.R.A.S.

Vice-Presidents.

ROBERT BARNES, M.D., F.R.C.P.
ROBERT WILLIAM PEREGRINE BIRCH, M.Inst.C.E., F.G.S.
CHARLES THEODORE WILLIAMS, M.A., M.D., F.R.C.P.
CAPTAIN DAVID WILSON-BARKER, F.R.G.S.

Treasurer.

HENRY PERIGAL, F.R.A.S., F.R.M.S.

Secretaries.

FRANCIS CAMPBELL BAYARD, LL.M.
GEORGE JAMES SYMONS, F.R.S.

Foreign Secretary.

ROBERT HENRY SCOTT, M.A., F.R.S.

Council.

ARTHUR BREWIN.
GEORGE CHATTERTON, M.A., M.Inst.C.E.
RICHARD HENRY CURTIS.
WILLIAM HENRY DINES, B.A.
WILLIAM ELLIS, F.R.S.
CHARLES HARDING.
BALDWIN LATHAM, M.Inst.C.E., F.G.S.
ADMIRAL JOHN PEARSE MACLEAR, R.N., F.R.G.S.
EDWARD MAWLEY, F.R.H.S.
HUGH ROBERT MILL, D.Sc., F.R.S.E., F.R.G.S.
HENRY SOUTHALL, F.R.H.S.
HERBERT SOWERBY WALLIS.

February 20th, 1895.

Ordinary Meeting.

RICHARD INWARDS, F.R.A.S., President, in the Chair.

MRS. CHARLOTTE LYNDON, Wellington, Somerset;
ARTHUR HENRY AYLMER MORTON, M.A., Athenæum Club, S.W.;
EDWARD AMOS PEAK, Pearson Park, Hull; and
CAPT. HENRY ROBERT FREDERICK PLATER, F.R.G.S., 18 Campbell Road, Bow,
were balloted for and duly elected Fellows of the Society.

CAPT. D. WILSON-BARKER and MR. W. MARRIOTT exhibited some lant slides showing the condition of the ice on the Thames at the date of the meetin

The following communications were read:—

"REPORT ON THE PHENOLOGICAL OBSERVATIONS FOR 1894." By EDWA MAWLEY, F.R.Met.Soc. (p. 112.)

"THE THUNDERSTORM AND SQUALL OF JANUARY 23RD, 1895." By WILLI MARRIOTT, F.R.Met.Soc. (p. 102.)

"ON SOME GRADUAL WEATHER CHANGES IN CERTAIN MONTHS AT GREENWI AND GENEVA." By ALEXANDER B. MACDOWALL, M.A., F.R.Met.Soc. (p. 108

CORRESPONDENCE AND NOTES.

Experiment illustrating the Formation of the Tornado Cloud.—The following experiment is so easily performed, and imitates so exactly on a small scale the mechanism of a Tornado or Waterspout, that it seems worth describing.

Obtain an old box or packing case about 2 feet square and 18 inches high. In the centre of the top cut a round hole about 3 inches diameter, and in it fix a few feet of stove pipe. Remove one side of the box, or preferably, for the sake of light, two opposite sides, and replace by window glass, leaving, however, a narrow opening on one side only between the glass and the side, about ½ inch to 1 inch broad and extending to the full height. Place in the bottom of the box a circular vessel filled with hot water, and then by any available means obtain a strong draft up the stove pipe. The characteristic funnel cloud is soon seen extending from the water to the mouth of the pipe at the top of the box, and if the draft be strong, and the conditions favourable, a decided protuberance is seen on the surface of the water just under the end of the cloud.

The draft can be obtained by burning a jet of gas in the stove pipe, and this is sufficient to form the cloud, but will hardly raise the protuberance on the water.

The success of the experiment seems to depend on a strong draft up the chimney, and on directing the air as it enters the box so that it has the greatest possible angular momentum about the centre, and also on perfectly quiet and steady conditions in the surrounding air, for the funnel when formed is easily broken up by any irregular draft.

There seems no doubt but that the cloud is formed by true dynamic cooling, as the air, saturated by the vapour from the hot water, comes under the influence of the decreased pressure at the centre; for I have not been able to form the cloud with smoke.

The circular motion and the rapid whirl are quite apparent, and can be proved by dropping any light objects into the box, also powder or soap suds floating on the water are instructive.

Probably the sizes given above are quite immaterial, but they are the first and only ones I have tried.—W. H. DINES, Oxshott, April 18th, 1895.

Wet-bulb in Frost.—During the frost of February 1895 I made several experiments with the wet-bulb thermometer in order to see how long it would take to fall to its lowest temperature after wetting.

1. On February 8th, at 9 p.m., I applied warm water to the ordinary wet-bulb thermometer with spherical bulb, and to a sling thermometer with long cylindrical bulb which had a fringe at the upper part of the bulb (Kammerman's arrangement): the temperature of both immediately rose to 50°. At the end of 1 minute both thermometers had fallen to 32°. The sling thermometer remained at that temperature for about 1 minute, and 3 minutes later had fallen to its lowest point. The ordinary wet-bulb thermometer remained at 32° for more than 5 minutes, and fell very slowly for the first few degrees, but more quickly for the remainder. This thermometer took about 10 minutes to fall. The whole time occupied from the moment of wetting, till the actual lowest temperature was reached, was 5 minutes for the sling thermometer, and 15 minutes for the ordinary wet-bulb thermometer.

The temperature of the air at the time was 18°, the wind East, force 2, and the sky cloudless.

2. On February 11th the muslin on the ordinary thermometer was wetted at 9 p.m., but on looking at the thermometer at the end of 30 minutes the mercury in it was still 2° higher than that of the dry bulb.

The temperature of the air was 22°, the wind calm, and the sky cloudless.

3. On February 14th I experimented with three thermometers, viz. the ordinary spherical bulb, a sensitive cylindrical bulb, and the sling thermometer. On applying warm water they all rose to about 50°, and at the end of 1 minute they had fallen to 32°. The sling thermometer remained at 32° for about 5 minutes, and at the end of 8 minutes had reached its lowest point. The cylindrical bulb thermometer remained at 32° for 8 minutes, and reached its lowest point in 12 minutes. The ordinary thermometer remained at 32° for 8 minutes, and reached its lowest point in 15 minutes.

The temperature of the air was 24°, the wind East, force 2, and the amount of cloud 7.

In these experiments the sling thermometer was whirled round and round in free air, while the other thermometers were suspended in the Stevenson screen.—WILLIAM MARRIOTT.

Smoke of Volcanoes as a Weathercock.—Some of us read with interest the article on the "Great Frosts" of mediæval and recent times in the *Standard* a few days ago—qualified with a smile at the legend that "the Mediterranean twice froze over, and that carts passed over it," &c. These were of course the lagoons of Venice and kindred seas. But the writer ended by asking how these great and continued frosts arose, and it is this part of the article—unanswerable at present though it be—that makes me ask whether the finest weathercocks in the world—the smoke of its lofty volcanoes—have been properly and systematically observed? I say weathercocks, for the (smoke) vane is free to move both laterally and perpendicularly; and it is as to this latter function that I ask my question. I have long been of opinion, from reading both British and Continental works on meteorology, that the importance of "down draughts" has not received the attention due to it.

On my re-visit to Naples (after many years absence) on December 20th, 1894, I arrived during the first veering of the wind towards North after cyclonic conditions. The next morning, with the wind West, the smoke of Vesuvius, which is somewhat abundant, blew away parallel with the clouds to the east, but the day following (the 22nd) the wind was North, and the smoke made a clinging descent down the side of the mountain to, of course, south. This continued for days, *i.e.*, while the wind was North or North-east, till the 25th. On the 26th the wind was East, and the smoke did not cling so much to the mountain surface, though its descending character was strongly marked. On the morning of the 27th, with light air from the East, with the same tendency, till near noon, with a bright sun, the wind drew to the South-west, and the smoke became thoroughly uplifted to the north-east. On the 28th there was the same uplifted tendency with the same wind till the afternoon, when the wind changed to East, and immediately there was a descent of the smoke, which lasted till the morning

of the 29th; when, with a rapid fall of the thermometer, the wind shifted to South-south-west and an uplifted, and afterwards horizontal, course of the smoke was observable wherever the clouds in the gale admitted of observation.

Over and over again in the last two months the same thing has occurred whenever in this most extraordinarily tempestuous winter I have been able to catch a glimpse of the smoke. At the moment of writing, the wind has suddenly turned, after sirocco, with great force to the North-east, and, as seen from here, the smoke descended from the mountain, which is almost due north from here, absolutely giving the semblance of a close cling to the side of the mountain. A very long and constant acquaintance with the Alps has taught me long ago that the cold of the Swiss "bise" and Italian "tramontano" from North to North-east has nothing to do, except for a most secondary thing, with the wind's passage over the Alpine snow. Compared with the cold derived from its down draught character, this passage may be almost considered "une quantité negligeable," *e.g.* take the May of 1891 when I was, as I often have been, at Lucerne. The first part of that month was unusually hot, and the surface of the plain north of Lucerne, to distinguish them from mountains, must have been for the time of year warm, yet on a sudden change to North the wind was, as anyone might have expected, bitterly cold. While a change to South in June, travelling over 50 miles of snow and glacier, brought, as it always does at Lucerne, an intolerable heat.

My impression is that the question of descent of air, more or less (as it is), of such long continuance where in winter we have such large areas of excessive pressure is one of those that has not received the attention it deserves; although I am, of course, quite aware of the valuable information in respect of it given in the text books. We know, *e.g.* that in the formation of hail the ascent and descent of the wind and the respective portions of the funnel shaped storm, are the factors of formation, but what here goes on in miniature goes on on a huge and lasting scale at times.—T. H. MORGAN, Sorrento, South Italy, February 16th, 1895.

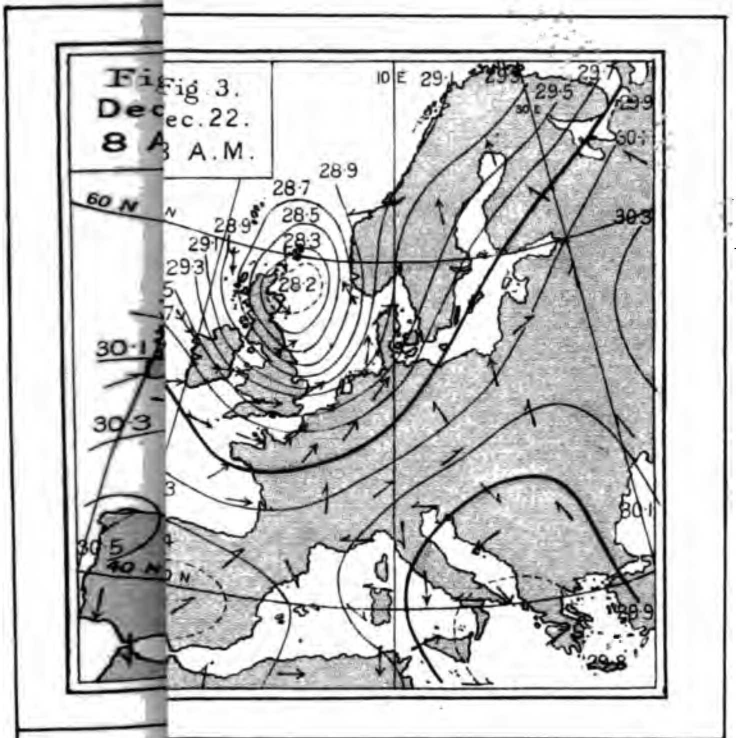


Fig. 3.
Dec. 22.
8 A.M.

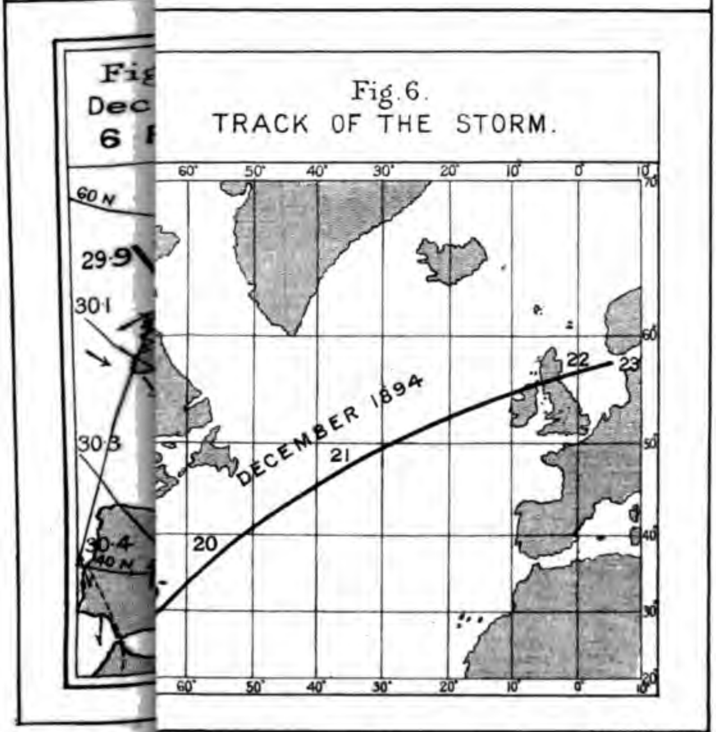


Fig. 6.
TRACK OF THE STORM.

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THE FROST OF JANUARY AND FEBRUARY 1895 OVER THE BRITISH ISLES.

BY F. CAMPBELL BAYARD, LL.M., F.R.Met.Soc.,

AND

WILLIAM MARRIOTT, F.R.Met.Soc.

(Plates 3-5.)

[Read April 17th, 1895.]

THE frost of January and February 1895 was of so intense a character, that it seemed desirable that a communication on the subject should be made to the Society. We have therefore willingly complied with the request of the Council to prepare such a paper, which we now submit, and trust that the information contained therein may be of interest to the Fellows.

The cold period, which commenced on December 30th, and terminated on March 5th, was broken by a week's mild weather from January 14th to 21st, otherwise the cold would have been continuous for 66 days. The character of the weather during this period will be seen at a glance from the following data for Greenwich :

				Mean.	
				Max.	Min.
A.	Dec. 30—Jan. 13	Cold		37·9	31·0
	Jan. 6—12		Very Cold	32·5	27·2
B.	Jan. 14—21	Mild		45·4	37·0
C.	Jan. 22—Mar. 5	Cold		35·9	24·1
	Jan. 26—Feb. 19		Intensely Cold	32·8	19·6

Minimum Temperatures.

We have plotted on maps for each day, for the whole period, the minimum temperatures from the Society's stations and also from those of th Meteorological Office, as well as some furnished by Dr. Buchan an Mr. Symons.

For the purposes of this paper we have considered a "cold day" to b when the minimum temperature has fallen below 10°. During the period i question there were 28 days on which that limit was reached in some part (the British Isles. The charts for these days are reproduced on Plates 3 an 4. The isothermal lines are drawn for each ten degrees, the areas below 1(being shaded, and those below 0° (zero) being cross shaded.

On January 8th, the temperature fell to −8° at Braemar, and was belo 10° over the central part of north Scotland. Temperatures below 20° wei recorded over nearly the whole of the north of Scotland, and also at severi places in England and Ireland.

On the 9th, the lowest reported temperature was −5° at Braema Temperatures below 10° were recorded over the central part of Scotland, whil readings below 20° were registered over nearly the whole of Scotland, tl north and parts of the west of England, and part of Wales and Ireland.

On the 10th, the cold areas had extended and the frost had become moi intense. The lowest temperatures were −2° at Braemar, and 0° at Stob Readings below 10° were reported from the eastern and southern parts of Sco land, and a part of the north Midlands of England and Wales. Temperatur below 20° occurred over practically the whole of Scotland, the greater pa of England and Wales, and the central part of Ireland.

On the 11th, the lowest reading was 0° at Braemar. The area of temper tures below 10° extended from the north of Scotland to the Midland counties England, while that below 20° covered nearly the whole of Scotland ai England.

On the 12th, the lowest reading was 2° at Hillington, and temperatur below 10° occurred in several districts in the east of Scotland and Englan Temperatures below 20° were recorded over the greater part of Scotla and England.

On the 13th, the cold had become less intense, only one station in tl north of England reporting a temperature below 10°, while readings bel 20° were recorded at only a few stations in the east of England.

Mild weather set in on the 14th and continued till the 21st, when tl

cold returned; and on the 26th the minimum had fallen below 10° in Wales and Norfolk, the lowest readings being 8° at Llandovery and 9° at Hillington. Temperatures below 20° occurred over the inland parts of Scotland, the north, east, and west of England, Wales, and part of Ireland.

On the 27th, temperatures below 10° were registered in the eastern and south-eastern counties, Yorkshire, and part of Wales, the lowest readings being 1° at Hillington and 8° at Geldeston. The temperature fell below 20° over almost the whole of England, Wales, and Scotland, and parts of Ireland.

On the 28th, the temperature fell below 0° in Wales, the lowest reading being −2° at Llandovery. Temperatures below 10° occurred over part of Wales, the north of England, and the west and south of Scotland; and minima readings below 20° were registered over almost the whole of England, Wales, and Scotland, as well as over the central part of Ireland.

On the 29th, temperatures below 10° were registered at several places in England, Wales, and Scotland, the lowest reading being 2° at Llandovery. Temperatures below 20° were reported from stations over nearly the whole of England and Wales, and the south and east of Scotland.

On the 30th, the temperature fell below 10° over the centre and south of Scotland, and parts of the centre of England, the lowest readings being 1° at Braemar and 8° at Stobo. Temperatures below 20° occurred over nearly the whole of Scotland, England, and Wales.

On the 31st, temperatures below 10° were registered over the central and southern parts of Scotland and part of Wales, the lowest readings being 2° at Braemar and 4° at Stobo. The temperature fell below 20° over nearly the whole of Scotland, the north and west of England, the greater part of Wales, and the south-west of Ireland.

From February 1st to 4th the cold was not so severe, the minimum temperature at no place being below 10°.

On the 5th, temperatures below 10° were registered over Wales and parts of the centre of England, the lowest reading being 5° at Gwernyfed Park, Brecknockshire. The minima fell below 20° over the greater part of England and Wales, and at a few stations in Scotland.

On the 6th, temperatures below 0° were registered at several places in the Midland districts of England, the lowest readings being −4° at Barkby, −3° at Ketton, and −2° at Bury St. Edmunds. The minima fell below 10° over the whole of the midland and part of the south-western districts of England, and part of Wales and Ireland; and also below 20° over the whole of England and Wales, and the greater part of Scotland and Ireland.

On the 7th, temperatures below 0° were registered at several places in England, Scotland, and Ireland, the lowest readings being −10° at Barkby, −7° at Aviemore, Inverness-shire, and −4° at Ketton. Temperatures below 10° occurred over the greater part of England and Wales, the centre and south of Scotland, and the centre of Ireland; while the isothermal line of 20° embraced almost the whole of the British Isles.

On the 8th, temperatures below 0° were registered over the centre and

south of Scotland, the north, centre, and other parts of England and Wales, the lowest readings being $-13°$ at Aviemore, and $-12°$ at Braemar. The area of temperatures below 10° embraced almost the whole of Scotland and England except the west and south, and also part of the centre of Ireland. Temperatures below 20° occurred over the whole of Scotland, Wales, and England (except the extreme south-west coast), and the greater part of Ireland.

On the 9th, temperatures below 0° were registered over the centre and south of Scotland, the north and midland districts of England, and part of Wales, the lowest readings being $-11°$ at Braemar and Aviemore, $-9°$ at Glenlee, and $-8°$ at Blair Athol. The area of temperatures below 10° was similar to that of the previous day, and embraced almost the whole of Scotland, England, and Wales, except the west and south, and also part of the centre of Ireland. Temperatures below 20° occurred over the whole of Scotland, Wales, and England (except the south-west coasts), and the north-east of Ireland.

On the 10th, temperatures below 0° were registered over the centre and south of Scotland, the north, centre, and east of England, and part of Wales, the lowest readings being $-14°$ at Braemar, $-13°$ at Blair Athol, and $-11°$ at Drumlanrig. The area of temperatures below 10° embraced nearly the whole of Scotland and the north, east, and centre of England, and part of Wales. Temperatures below 20° occurred over the whole of Scotland, nearly the whole of England and Wales, and parts of Ireland.

On the 11th, temperatures below 0° were registered over the central and southern parts of Scotland, and in Derbyshire, the lowest readings being $-17°$ at Braemar, and $-11°$ at Buxton. Temperatures below 10° occurred over the greater part of Scotland, and the north, east, and midland districts of England, and below 20° over the whole of Scotland, the greater part of England, and also in Wales and Ireland.

On the 12th, temperatures below 0° were registered over the south of Scotland, the lowest reading being $-8°$ at Drumlanrig. Temperatures below 10° occurred over the north, centre, and south of Scotland, the north, east, west, and other parts of England, Wales, and parts of Ireland. The area of temperatures below 20° embraced almost the whole of the British Isles.

On the 13th, temperatures below 0° were registered over the centre and south of Scotland, the lowest reading being $-7°$ at Braemar. Temperatures below 10° occurred over the central and southern parts of Scotland, the greater part of England and Wales, and the centre of Ireland. The area of temperatures below 20° embraced almost the whole of Scotland, England, and Wales, and parts of Ireland.

On the 14th, the lowest minimum reported was $-7°$ at Drumlanrig. Temperatures below 10° occurred over parts of Scotland and England; and the isothermal line of 20° embraced almost the whole of Scotland, England, and Wales.

On the 15th, temperatures below 10° were reported from Leicestershire and the south of Scotland, the lowest being 8° at Loughborough. Tempera-

tures below 20° occurred in the north and south of Scotland and the greater part of England and Wales.

On the 16th, the temperature fell to $-11°$ at Aviemore, and was below 10° over the centre and south of Scotland. Temperatures below 20° occurred over the greater part of Scotland, and several parts of England and Wales.

On the 17th, the temperature fell to $-11°$ at Aviemore, and $-9°$ at Braemar, and was below 10° over the central parts of Scotland, and the east and south-east of England. Temperatures below 20° occurred over nearly the whole of Scotland, and most of the southern half of England, and part of Wales.

On the 18th, the temperature fel to $-11°$ at Aviemore, and $-7°$ at Braemar, and was below 10° over the central part of Scotland. Temperatures below 20° occurred over the greater part of Scotland and England, and parts of Wales and Ireland.

On the 19th, the temperature fell to $-8°$ at Aviemore and Braemar, and was below 10° over the central and southern parts of Scotland. Temperatures below 20° occurred over almost the whole of Scotland, and at several places in England and Ireland.

On the 20th, the temperature fell to $-5°$ at Braemar, and 0° at Drumlanrig, and was below 10° over the central and southern districts of Scotland. Temperatures below 20° occurred over nearly the whole of Scotland, the north-west and other parts of England, Wales, and the north-west of Ireland.

After this date no readings below 10° were recorded, although frost occurred on every day, during the remainder of the cold period, in some part of the British Isles.

Mean Temperatures.

Table I. gives the mean maximum and minimum temperatures at a number of stations for January and February; for the period of intense cold, January 26th to February 19th; and also for the whole period, December 30th to March 5th.

On Plate 5 are given charts of mean temperature for January and February, and also for comparison Dr. Buchan's charts of the average temperature for the period 1857-1880. From these charts it will be seen that the mean temperature of the British Isles for January was about 7°, and for February was from 11° to 20°, below the average.

On Plate 5 are also given the charts of mean temperature for the whole period, December 30th to March 5th; and for the period of intense cold, January 26th to February 19th.

Table II. gives the number of times during January and February the maximum temperature was 32° or below, 25° or below, and the lowest reading; as well as the number of times the minimum temperature was 20° or below, 10° or below, and the lowest reading.

The intensity of the frost may be gathered from the fact that there were 19 days on which the temperature fell below 0°, and 28 days on which it was below 10°, in some part of the British Isles.

TABLE I.—MEAN MAXIMUM AND MINIMUM TEMPERATURES.

Station.	January.		February.		Jan. 26 to Feb. 19.		Dec. 30 to March 5.	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
SCOTLAND, N.	°	°	°	°	°	°	°	°
Sumburgh Head	37·7	31·3	37·5	29·0	35·6	26·8	37·5	29·9
Deerness	37·6	30·9	36·8	29·8	34·9	27·9	37·2	30·0
Stornoway	38·7	29·6	41·1	27·4	38·9	24·6	39·7	28·6
Scourie	40·5	27·8	39·9	24·1	37·7	21·2	40·2	26·0
Wick	37·5	27·8	37·4	24·0	35·4	21·2	37·4	26·2
Glencarron	35·2	23·9	35·2	22·6	32·2	18·4	35·4	23·4
Fort Augustus	36·1	23·5	36·9	21·6	33·8	17·5	36·6	23·0
Fort William	37·3	27·2	37·0	25·1	33·9	21·8	37·3	26·6
SCOTLAND, E.								
Nairn	36·2	24·7	36·7	17·3	33·7	12·5	36·5	21·9
New Pitsligo...	35·1	25·3	35·2	21·8	33·8	18·4	35·2	23·8
Aberdeen	36·1	27·0	35·4	22·9	32·6	19·9	36·0	25·5
Logie Coldstone	33·4	22·4	32·3	19·4	29·1	15·2	33·1	21·4
Braemar	31·6	18·0	30·6	12·3	27·1	6·9	31·3	16·1
Fettercairn	36·1	25·1	36·5	19·3	33·7	16·2	36·6	22·9
Montrose	35·0	26·0	35·3	22·5	32·6	19·9	35·5	24·6
Lednathie	34·0	21·7	35·1	17·1	32·1	13·6	34·6	20·1
Ochtertyre	35·8	24·8	38·9	21·7	35·3	18·5	37·6	23·8
Stronvar	34·0	21·3	37·0	18·5	32·8	15·6	35·7	20·6
Dollar	35·6	27·5	35·4	24·1	33·4	22·6	35·9	26·3
Leith...	37·5	27·1	38·5	24·8	35·6	22·2	38·4	26·5
Edinburgh	36·2	27·5	37·1	25·4	34·0	22·9	37·0	26·9
Marchmont	35·1	25·3	34·2	24·1	31·7	21·1	34·6	25·0
Stobo...	34·4	18·7	33·2	15·8	29·7	12·1	34·5	18·0
Hawick	34·0	22·5	34·5	20·5	31·6	17·4	34·8	22·1
ENGLAND, N.E.								
Alnwick	36·0	27·9	35·1	25·4	32·6	23·5	35·7	27·0
North Shields	37·6	27·5	36·9	25·5	34·3	23·6	37·5	26·8
Durham	35·1	25·4	35·8	23·3	33·1	20·3	35·8	24·7
Aysgarth	33·2	24·7	33·0	21·6	29·9	19·0	33·3	23·6
Scarborough	37·7	28·7	36·7	27·0	33·6	24·8	37·9	28·1
York	36·3	26·2	36·4	22·9	33·6	20·0	36·7	25·0
Spurn Head	37·9	30·8	35·6	28·8	33·9	26·8	36·9	29·8
ENGLAND, E.								
Hillington	36·6	24·8	35·6	21·5	32·8	16·6	36·4	23·8
Yarmouth	37·5	28·8	34·8	26·9	32·6	23·6	36·4	28·0
Geldeston	38·6	26·8	36·3	22·8	34·3	18·9	37·9	25·2
Cambridge	37·3	26·8	36·9	20·7	33·8	16·5	37·5	24·3
Rothamsted	36·5	27·3	34·3	20·6	31·1	16·4	35·8	24·6
MIDLAND COUNTIES.								
Hesley Hall, Bawtry	36·2	25·9	36·6	20·5	33·5	16·4	36·7	23·9
Belvoir Castle	35·4	25·0	34·4	20·1	31·7	16·1	35·3	23·3
Loughborough	36·9	25·8	36·6	17·3	33·7	12·2	37·1	22·5
Ketton	36·7	26·1	36·4	17·5	33·2	13·3	37·0	22·8
Cheadle	34·9	25·5	33·8	23·0	30·9	20·1	34·8	24·7
Solihull	35·1	26·9	33·9	20·9	30·9	17·4	34·9	24·6
Churchstoke	35·7	24·1	33·6	18·9	30·9	15·2	35·1	22·2
Burghill	37·0	27·5	34·9	19·3	32·1	15·9	36·5	24·2
Cirencester	37·4	26·3	33·7	21·1	30·7	17·4	36·0	24·2
Oxford	37·4	28·6	35·4	21·6	32·4	18·3	36·8	25·6
ENGLAND, S.								
London (Brixton)	38·2	29·9	35·6	23·0	32·6	19·8	37·3	26·9
Greenwich	37·7	29·5	35·2	22·8	32·3	19·6	36·9	26·7
Cooper's Hill	37·3	28·9	33·8	22·8	31·0	19·6	36·1	26·3

TABLE I.—MEAN MAXIMUM AND MINIMUM TEMPERATURES—*Continued.*

Station.	January. Max.	January. Min.	February. Max.	February. Min.	Jan. 26 to Feb. 19. Max.	Jan. 26 to Feb. 19. Min.	Dec. 30 to March 5. Max.	Dec. 30 to March 5. Min.
ENGLAND, S.—*Continued.*	°	°	°	°	°	°	°	°
North Foreland	38·9	30·5	34·3	26·1	32·5	23·7	36·8	28·6
Strathfield Turgiss	37·7	27·9	36·2	19·1	33·0	16·4	37·4	24·1
Dungeness	38·9	30·1	34·9	23·7	32·7	21·3	37·0	27·1
St. Leonard's	38·4	30·3	34·3	25·8	31·7	23·5	36·6	28·2
Southampton	39·8	29·9	37·5	23·9	34·5	21·4	39·1	27·4
Hurst Castle	40·1	31·5	35·9	25·5	33·9	23·6	38·5	28·8
Stowell	37·7	27·3	33·9	21·7	31·6	18·5	36·3	25·0
SCOTLAND, W.								
Laudale	38·9	26·9	37·7	25·1	34·4	23·2	38·7	26·2
Duntreath	35·8	...	37·2	22·2	33·2	...	37·0	...
Glasgow	35·6	27·5	35·5	24·6	32·3	22·2	35·9	26·6
Ardrossan	37·3	28·8	37·5	25·5	34·1	23·0	37·8	27·8
Drumlanrig	37·6	24·5	37·1	15·8	34·8	13·8	37·7	21·1
Glenlee	35·4	24·3	34·1	18·1	31·5	15·7	35·3	22·1
Cronkbourne, Isle of Man	39·4	31·6	38·1	26·9	35·9	26·2	38·9	29·6
ENGLAND, N.W.								
Hawes Junction	31·9	21·5	30·3	19·0	27·7	16·3	31·3	20·5
Stonyhurst	35·0	27·4	34·1	24·3	31·6	21·8	34·9	26·3
Blackpool	38·4	26·9	35·8	22·7	34·3	20·0	37·5	25·5
Prestwich	36·6	26·4	35·1	23·1	32·7	20·9	36·4	25·1
Bidston	36·9	29·8	34·5	25·0	32·4	23·1	36·1	28·0
Llandudno	39·3	32·2	36·2	27·3	34·4	25·3	38·1	30·2
Holyhead	40·5	33·3	37·2	28·3	35·6	26·7	39·2	31·2
ENGLAND, S.W.								
Llandovery	37·7	23·9	36·2	18·4	33·0	14·5	37·4	21·8
St. Ann's Head	41·8	34·8	37·0	27·9	35·3	26·6	39·7	31·8
Bristol	38·6	29·5	35·5	22·2	32·9	19·3	37·8	26·5
Arlington	38·6	29·0	33·5	22·9	31·3	20·7	36·5	26·5
Cullompton	39·8	28·3	36·1	22·7	33·9	20·2	38·5	26·4
Prawle Point	42·2	31·9	37·3	28·6	35·5	26·8	40·1	30·4
Plymouth	41·3	31·8	38·0	28·6	36·0	26·1	40·0	30·5
Falmouth	42·8	33·8	38·2	30·6	36·8	28·4	41·0	32·5
IRELAND, N.								
Malin Head	40·6	34·1	38·5	31·5	36·7	29·4	39·7	33·0
Londonderry	39·0	30·1	39·7	26·4	37·2	24·8	39·5	28·8
Edenfel (Omagh)	36·6	28·5	36·4	22·8	33·8	21·3	36·8	26·2
Belmullet	42·5	34·4	39·7	29·8	37·8	29·2	41·5	32·5
Markree	39·4	28·7	38·8	23·9	35·8	22·7	39·6	26·8
Colebrooke	40·3	27·5	38·8	22·6	36·8	21·2	39·6	25·6
Arley Cottage (Lough Sheelin) ...	37·3	27·8	37·4	23·7	34·7	23·3	37·8	26·2
Currygrane	37·2	27·7	37·0	23·0	34·3	21·6	37·5	25·9
Armagh	37·2	27·6	37·6	24·3	35·1	22·7	37·7	26·4
Donaghadee	40·3	32·5	39·0	29·4	36·7	28·4	39·9	31·2
IRELAND, S.								
Dublin	39·6	31·2	38·4	29·9	36·6	29·1	39·2	30·7
Parsonstown	38·9	28·8	38·1	23·9	35·9	23·0	38·8	26·9
Kilkenny	39·3	29·2	38·1	27·3	36·0	26·4	39·1	28·6
Roche's Point	43·6	34·4	41·4	32·4	39·9	32·4	42·8	33·7
Foynes	41·3	31·7	39·3	29·1	37·7	28·2	40·7	31·0
Killarney	43·7	31·4	40·6	28·2	39·2	29·1	42·7	30·1
Valencia	44·1	35·1	42·0	32·0	40·7	32·2	43·5	34·1
CHANNEL ISLANDS.								
Scilly	46·0	38·3	40·5	33·5	39·8	32·7	43·6	36·2
Jersey	43·5	34·9	35·6	27·3	34·0	25·9	40·0	31·7

TABLE II.—PARTICULARS OF MAXIMUM AND MINIMUM TEMPERATURES DURING JANUARY AND FEBRUARY 895.

Station.	Maximum.						Minimum.					
	January.			February.			January.			February.		
	32° or below.	25° or below.	Lowest.	32° or below.	25° or below.	Lowest.	20° or below.	10° or below.	Lowest.	20° or below.	10° or below.	Lowest.
SCOTLAND, N.			°			°			°			°
Sumburgh Head ...	3	...	29·0	4	1	25·0	...	...	22·2	2	...	17·0
Deerness	3	...	29·8	4	...	28·0	...	...	23·0	...	...	20·6
Stornoway	3	...	31·0	1	...	31·0	1	...	19·0	2	...	16·0
Scourie	1	...	30·0	2	...	30·0	3	...	20·0	13	...	14·0
Wick	3	...	32·0	3	...	28·0	4	...	14·0	9	3	2·0
Glencarron	7	1	24·5	7	3	23·2	9	1	9·1	10	1	8·6
Fort Augustus ...	6	1	24·0	6	...	26·3	11	3	4·9	13	5	4·2
Fort William ...	5	1	24·5	7	...	27·2	4	...	10·8	10	...	11·0
SCOTLAND, E.												
Nairn	3	...	26·0	7	...	26·0	10	3	5·0	15	12	0·0
New Pitsligo... ...	3	...	26·9	5	...	26·8	9	...	14·2	11	...	10·6
Aberdeen	7	...	25·4	7	2	19·0	6	1	9·9	12	5	5·6
Logie Coldstone ...	13	1	25·0	10	4	15·3	10	3	5·2	13	7	− 3·0
Braemar	14	4	18·2	16	6	14·0	13	8	−5·0	14	12	−17·0
Fettercairn	3	...	26·7	6	1	24·7	7	4	6·0	13	11	− 3·0
Montrose	7	...	26·6	6	2	22·6	4	...	12·3	11	4	3·3
Lednathie	9	2	21·5	8	2	21·0	13	5	5·0	14	11	− 3·0
Ochtertyre	4	1	22·0	6	1	24·0	8	1	10·0	13	5	4·0
Stronvar	9	4	17·0	8	1	24·0	12	5	4·0	15	9	2·0
Dollar	3	1	25·0	8	1	25·0	4	...	14·0	9	..	11·0
Leith	2	...	29·0	4	...	28·0	6	...	15·0	9	...	12·0
Edinburgh	3	...	29·8	6	1	24·5	3	...	19·0	9	...	11·9
Marchmont	7	...	30·0	8	2	11·0	8	...	14·0	10	2	7·0
Stobo...	13	2	20·0	13	6	20·0	16	8	0·1	16	8	0·0
Hawick	9	2	20·0	7	4	18·8	9	4	2·1	11	6	− 0·1
ENGLAND, N.E.												
Alnwick	6	...	26·0	9	2	23·0	3	...	11·0	9	2	4·0
North Shields ...	3	...	28·0	7	1	24·0	3	...	13·0	9	4	7·0
Durham	6	...	27·7	6	2	24·7	7	3	8·4	8	5	− 1·8
Aysgarth	9	1	24·0	9	4	21·4	7	...	10·1	10	5	− 2·1
Scarborough ...	4	...	26·3	4	3	21·3	1	...	18·4	5	1	8·1
York	5	...	27·0	8	1	23·0	7	...	12·0	9	4	3·0
Spurn Head	2	...	31·0	5	...	26·0	...	...	23·0	2	...	20·0
ENGLAND, E.												
Hillington	6	...	28·1	6	...	25·3	8	3	1·9	10	6	1·1
Yarmouth	1	...	29·0	9	1	25·0	3	...	11·0	4	...	15·0
Geldeston	1	...	29·1	6	1	25·0	5	1	8·0	9	3	1·4
Cambridge	4	...	28·2	5	...	26·6	7	...	15·0	13	5	5·5
Rothamsted	8	...	26·2	9	2	22·8	4	...	14·5	14	4	2·5
MIDLAND COUNTIES.												
Hesley Hall, Bawtry	5	...	30·0	6	2	23·0	8	1	9·0	13	7	− 1·0
Belvoir Castle ...	8	1	25·0	10	2	24·0	11	2	10·0	12	6	− 3·0
Loughborough ...	6	1	24·0	7	...	26·4	7	2	9·0	13	11	− 5·0
Ketton	5	...	30·0	7	...	26·0	7	...	12·0	14	9	− 8·0
Cheadle	8	...	27·4	9	2	24·5	6	...	15·0	10	...	11·2
Solihull	10	1	21·3	11	2	22·3	7	...	11·3	11	4	0·5
Churchstoke... ...	5	...	27·5	12	2	23·4	9	1	9·6	15	5	0·2
Burghill	6	...	28·5	8	1	21·6	5	...	16·0	12	7	− 3·2
Cirencester	7	...	28·0	11	2	24·0	9	...	11·0	13	6	6·0
Oxford	8	1	24·0	8	2	24·0	6	...	13·0	13	4	7·0
ENGLAND, S.												
London (Brixton) ...	5	...	30·0	9	1	24·0	1	...	18·0	12	1	10·0
Greenwich	6	...	28·7	11	...	27·0	...	...	20·3	11	2	6·9
Cooper's Hill ...	6	...	26·9	11	2	23·4	1	...	19·1	13	...	10·1

TABLE II.—PARTICULARS OF MAXIMUM AND MINIMUM TEMPERATURES DURING JANUARY AND FEBRUARY 1895—*Continued.*

Station.	Maximum.						Maximum.					
	January.			February.			January.			February.		
	32° or below.	25° or below.	Lowest.	32° or below.	25° or below.	Lowest.	20° or below.	10° or below.	Lowest.	20° or below.	10° or below.	Lowest.
ENGLAND, S.—*Cont.*			°			°			°			°
North Foreland ...	...	...	33·0	12	1	24·0	...	...	22·0	5	...	18·0
Strathfield Turgiss ...	7	...	27·0	7	...	25·3	2	...	19·1	13	5	1·8
Dungeness	2	...	30·0	9	1	25·0	1	...	19·0	10	...	13·0
St. Leonard's ...	3	...	28·2	12	2	23·2	...	...	21·9	...	...	20·3
Southampton ...	3	...	27·6	5	...	26·3	1	...	19·1	6	...	13·7
Hurst Castle ...	2	...	32·0	6	...	27·0	1	...	20·0	4	...	17·0
Stowell	9	...	26·6	11	1	23·5	4	...	13·6	13	1	9·5
SCOTLAND, W.												
Laudale	4	...	27·0	6	...	25·9	4	...	16·0	7	...	16·8
Duntreath	7	2	19·0	7	2	23·0	?	?	?	12	5	6·0
Glasgow	4	1	23·9	8	3	22·3	3	...	15·0	7	1	6·6
Ardrossan	2	...	32·0	6	3	22·0	2	...	19·0	6	...	13·0
Drumlanrig	1	...	29·4	7	...	25·4	7	1	8·0	14	8	−11·0
Glenlee	6	...	29·0	11	4	16·2	10	...	12·0	14	8	− 5·0
Cronkb'ne, I. of Man	...	...	34·9	3	...	28·0	...	...	20·5	4	...	10·5
ENGLAND, N.W.												
Hawes Junction ...	16	1	25·0	16	6	19·0	13	1	8·0	14	4	3·0
Stonyhurst	7	...	27·5	10	4	23·7	3	...	18·9	8	...	10·5
Blackpool	2	...	27·6	6	1	23·3	7	...	12·0	12	2	9·9
Prestwich	4	...	29·8	7	2	21·8	7	...	16·9	10	...	10·6
Bidston	6	...	27·0	8	2	22·0	...	...	22·0	7	...	12·0
Llandudno	...	...	33·0	6	...	25·5	...	...	24·8	4	...	17·5
Holyhead	...	...	33·0	4	...	27·0	...	...	28·0	2	...	17·0
ENGLAND, S.W.												
Llandovery	5	...	27·0	9	...	26·0	10	3	−2·0	15	5	3·0
St. Ann's Head ...	1	...	30·0	5	...	29·0	...	...	27·0	...	...	23·0
Bristol	3	...	27·7	7	...	25·8	2	...	18·0	12	...	10·5
Arlington	4	...	28·0	11	1	23·0	3	...	16·0	9	...	13·0
Cullompton	1	...	28·4	6	...	25·8	3	...	15·6	7	...	11·3
Prawle Point ...	1	...	32·0	4	...	29·0	...	...	25·0	...	...	21·0
Plymouth	...	...	34·0	2	...	29·6	...	...	22·0	1	...	19·0
Falmouth	...	...	34·8	1	...	31·5	...	...	25·4	...	...	22·3
IRELAND, N.												
Malin Head	...	...	34·0	5	...	30·0	...	...	27·0	1	...	20·0
Londonderry... ...	1	...	32·0	1	...	31·5	...	...	23·0	5	...	14·5
Edenfel (Omagh) ...	7	...	31·0	7	...	28·0	3	...	19·0	9	2	5·0
Belmullet	...	...	36·0	3	...	30·0	...	...	29·0	...	...	23·0
Markree	1	...	31·0	2	...	30·0	2	...	16·3	5	2	1·6
Colebrooke	...	...	33·0	2	...	30·0	5	...	14·2	10	4	− 2·0
Arley Cottage (Lough Sheelin) ...	1	...	30·8	4	...	28·8	4	...	16·1	6	2	2·0
Currygrane	3	...	31·0	5	...	27·0	3	...	18·5	5	3	0·0
Armagh	2	...	30·5	3	...	29·0	4	...	12·2	7	2	4·9
Donaghadee ...	...	...	35·0	3	...	30·0	...	...	25·0	5	...	16·0
IRELAND, S.												
Dublin	1	...	30·8	1	...	30·7	1	...	16·9	1	...	19·0
Parsonstown ...	...	...	32·5	3	...	29·5	3	...	19·3	4	3	6·0
Kilkenny	2	...	31·0	2	...	31·0	3	...	18·0	3	...	11·0
Roche's Point ...	...	...	36·0	...	...	36·0	...	...	27·0	...	...	25·0
Foynes	1	...	31·8	...	..	33·4	...	...	24·1	1	...	17·3
Killarney	...	...	37·0	...	...	33·0	3	...	19·5	4	...	14·5
Valencia	...	...	37·0	...	...	36·0	...	...	28·0	...	...	22·0
CHANNEL ISLANDS.												
Scilly	...	...	36·0	...	...	36·0	...	...	28·0	...	...	27·0
Jersey	...	...	35·0	6	...	25·1	...	...	26·1	2	...	18·1

Atmospheric Pressure.

During the period under review the distribution of atmospheric pressure over the British Isles was almost entirely the reverse of the normal. The pressure in January was lowest in the south, and highest in the north, the conditions being favourable for strong Northerly and Easterly winds. In February the conditions were more decidedly anticyclonic, but still the pressure was low in the south, the result being that the general direction of the wind was from the North-east or East.

It was owing to the persistent winds that prevailed during nearly the whole of this period that there was but little, if any, fog. This was one of the most remarkable features of the recent frost, as former frosts have almost invariably been accompanied with quiet anticyclonic conditions and consequently much fog.

Snow fell in the north on several occasions, and owing to the strong winds which blew at the time heavy snowdrifts occurred, which in many instances in Scotland completely blocked the railways. On February 8th a heavy fall of snow occurred over the north of Ireland and the Isle of Man, the melted snow at Donaghadee producing 1·59 in. of water.

Death Rate.

The effect of the cold on the public health was very great, especially on young children and old people. The total number of deaths in London was below the average till the week ending February 2nd, after which they rose with great rapidity until March 9th, when the registered number of deaths for that week was 3,471, or 1,583 above the average—the death rate being 41·2 per thousand. After this the number of deaths rapidly decreased, and by March 30th had almost fallen to the average. The dotted line shows the average death rate. (Fig. 1.)

The number of deaths due to diseases of the respiratory organs rapidly increased from February 2nd to March 2nd, when they were 1,448, or 945 above the average. They were slightly less during the next week, after which they declined to about the average by the end of the month. (Fig. 1.)

The number of deaths according to ages is shown in Fig. 2; from which it will be seen that there was comparatively little effect of the cold on people in vigorous health—that is between 5 and 40 years of age. The effect on middle aged people—that is between 40 and 60—was very pronounced, the deaths rising from 324 on February 2nd to 669 on March 9th. Children under 5 years of age suffered severely, the deaths rising from 462 on January 26th to 1,013 on March 9th. The effect of the cold on old people—that is above 60 years of age—was most remarkable, the number of deaths rising from 437 on February 2nd to 1,331 on March 2nd, and 1,368 on March 9th; being an increase of more than three times the number in four weeks.

Skating.

As a result of the frost, rivers, lakes, ponds, &c., all became fast bound in ice, and afforded ample scope for skating. In Regent's Park skating was

permitted on the lake from January 9th to 18th, and from the 29th to March 8th,—in all a period of 44 days. The ice was 10 inches thick on February 18th.

The Serpentine in Hyde Park is not thrown open for skating so much as formerly, as the authorities will not allow the public to go on the ice until it

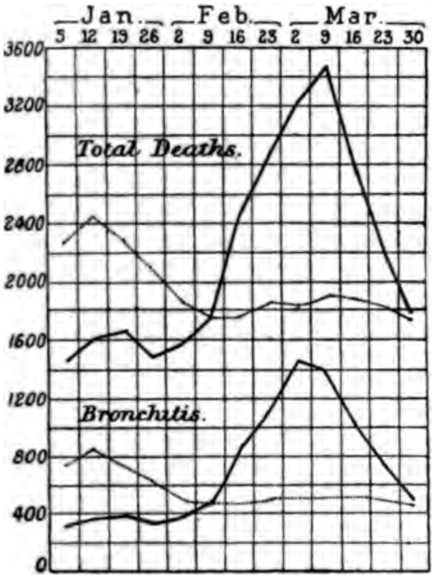


Fig. 1—Total Deaths in London, and also Deaths from Bronchitis.

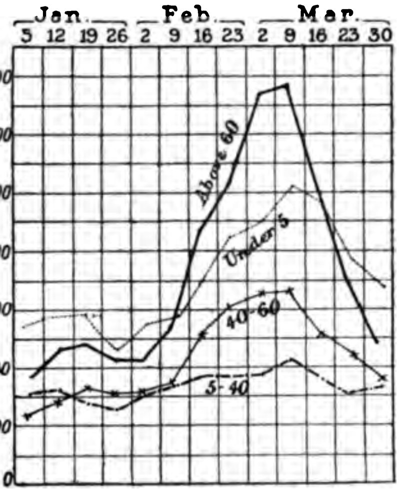


Fig. 2.—Deaths in London according to ages.

has attained a considerable thickness. There was skating on the Serpentine from February 8th to 21st. The ice was 7¼ inches thick on the 19th and 20th.

Vast numbers of people skated not only on the lakes in the London Parks, but also on all sheets of water all over the country. The railway companies ran special trains for skaters to Lake Windermere and Loch Lomond. The following extract from *The Westmoreland Gazette*, February 16th, will give some idea as to the enthusiasm with which skating was taken up :—

The lakes, chief among them Windermere, have been fast bound in ice. On Monday morning Windermere was one sheet of black ice, contrasting in this respect with most, if not all, of the other lakes, where the ice was spoilt by snow. The news of the freezing of the lake soon spread, and during the present week Windermere has been visited by thousands of skaters, as well it might, considering that the opportunity of skating over between three and four thousand acres of ice does not occur more than twice or thrice in a lifetime. That Bowness should be the great skating centre was inevitable, from its proximity to the railway station at Windermere and its accessibility to a considerable local population. Since Saturday the shore and the surface of the lake have presented a scene of the greatest animation. Troops of well dressed folk, carrying skates, have hurried down from the station, the crowds increasing as the week progressed. On Wednesday, when there were cheap bookings from Liverpool and Manchester, and a special train from Lancaster, the number of persons on the lake could not have been less than 2,000. The Bowness Urban District Council early took measures tending to the preservation of skaters from

risk, and their rescue in the event of accident. Ropes and ladders were deposited at various points along the shore; two men were appointed to keep watch, and at places where there were signs of weak ice, flags were planted. A row of flags was fixed along the north side of the track kept open by the ferry boat, which has plied to and fro as usual. Skaters wishing to get past Ferry Nab had to cross a small portion of the shore in order to do so. At a dangerous bit near Henholme a red lamp was put up to warn off skaters who ventured near after dark. Bonfires were lighted in front of the promenade, and Mrs. Richards, with her characteristic thoughtfulness, had a tall electric lamp put up on the lawn of the Old England Hotel. The boatmen were enabled to make a little money by putting on and taking off skates, using their cushion-houses for the purpose. Refreshments were served out on the ice, and two or three photographers were employed at intervals in "taking" groups of skaters. A brass band has been stationed on one of the islands, and to its strains many of the skaters have indulged in waltzing. On Wednesday, Mr. Geo. H. Pattinson, chairman of the Urban Council, drove across the ice in a sledge to the shore of Belle Isle. His example was afterwards followed, and his performance improved upon by a man in the employ of Mr. John Crosthwaite, who, with two other gentlemen, drove tandem over the ice. As night draws on, the skaters, of course, get fewer, but some of the more ardent, desirous perhaps of enjoying the novelty and charm of skating by moonlight, have skated far into the night. To such, the scene and the situation must have been of an impressive kind. The ice, smooth and clear, reflects the whitened hills like a mirror, and the echo of the ringing steel imparts a solemnising effect.

Mr. R. Waters, writing from Bowness on March 16th, said: "The lake is still covered with thick ice, with only here and there an open space. A gentleman skated from Bowness boat-landings to Henholme on Wednesday last, March 13th."

In the Fen district the ice was in some places 2 feet thick.

At Oxford a coach and six was driven over the Cherwell. (A photograph of this was shown to the meeting on the screen.)

On the Grand Junction Canal traffic was stopped for 32 days, although the ice boats, which are able to break and make a fair way through ice 7 to 8 inches thick, were kept running as long as possible.

Ice on the Thames.

Capt. D. Wilson-Barker, of H.M.S. *Worcester*, off Greenhithe, has supplied the following notes as to the ice on the Thames:—

"The ice floes began to accumulate at Greenhithe (18 miles below London) on February 7th, and daily got thicker until, on the 9th, nearly all communication, except for an hour or two at the top of high water, was completely cut off; and it was only by means of a hawser, rigged to the shore from the main topmast head, that we could get our mails off.

"From the 9th to the 17th the whole river was more or less completely blocked with ice, and there was little traffic, it being quite impossible for full-powered steamers to force their way up or down except with the tide. Barges were floating about adrift in all directions, and the ice floes were 6 and 7 feet, and even more, thick. But the ice was generally soft and brashy, and it is likely that much of it was due to the cartloads of snow which were shot into the river in London, and which from lying in the carts had become more or less compacted together, and practically went into the river as a semi-solid lump.

"The tides appeared to have been affected to a certain extent, and to have been somewhat irregular.

"In 1881, from about January 22nd to 29th, the river presented a somewhat similar spectacle, but the quantity of ice was not so great, and communication with the shore was much better kept up."

EARTH TEMPERATURES.

Table III. gives the lowest observed readings of the earth thermometers at the Society's stations from 3 inches to 2 feet below the surface. From this it will be seen that at the majority of the stations the temperature at 1 foot did not fall much below 32°. Three stations, however, report temperatures at 1 foot of nearly 28°, viz. Aspley Guise, Lowestoft, and Regent's Park. At the last two of these stations the thermometers have long tubes with their scales some 6 inches or more above the surface of the ground and this construction does not permit of verification at the inspection of the station. At the other stations the thermometers used are those known as Symons's pattern, or a modification of the same.

TABLE III.—LOWEST READINGS OF THE EARTH THERMOMETERS DURING FEBRUARY 1895.

Station.	3 inches.		6 inches.		1 foot.		2 feet.	
	Min.	Date.	Min.	Date.	Min.	Date.	Min.	Date.
	°		°		°		°	
Rounton	...	...	...	...	32·0	20	...	...
North Thoresby	28·4	11	30·8	14	32·2	16	34·8	16
Somerleyton	...	...	...	...	33·0	20	...	...
Lowestoft	...	...	...	...	28·2	21	31·9	19
Bennington	...	...	...	...	32·0	17	...	...
Hodsock	...	...	...	...	32·2	17	...	...
Southwell	...	...	...	...	32·0	12	...	...
Aspley Guise	26·6	10	27·3	10	28·4	14	32·4	17
Berkhamsted	...	...	...	...	30·6	14	32·9	17
Regent's Park	...	...	...	...	28·2	14	34·0	19
Norwood	...	...	...	...	32·1	17	...	...
Wallington	...	...	...	...	30·4	18	...	...
Tunbridge Wells	...	...	...	...	31·9	17	...	...
Marlborough	...	...	28·0	12	31·0	17	...	...
Harestock	...	...	...	...	31·7	15	34·4	27
Stowell	...	...	...	...	31·0	15	...	...
Margate	...	...	31·7	15	32·6	17	...	...
Worthing	...	...	...	...	32·8	18	...	...
Portsmouth	...	...	...	...	32·0	...	...	...
Bolton	...	...	27·4	13	31·0	13	33·2	23
Rousdon	...	...	...	...	31·7	16	35·5	22
Tavistock	...	...	32·1	18	33·4	23	...	...

FROZEN WATER MAINS.

The frost will long be remembered for its effect on the water pipes all over the country, in many cases householders being without water for more than nine weeks.

Mr. E. Pritchard, M.Inst.C.E., of Birmingham, who has been making inquiries on this subject at about 60 towns in various parts of the country, informs us that mains have been frozen which were laid so low as 3 ft. 3 ins.

and 3 ft. 6 ins. respectively from the surface of the ground to the top of the pipe. The following are the depths at which mains have been frozen at several towns:—

	ft.	in.		ft.	in.
Alcester	2	6	London—G. J. W. ...	2	4
Braintree	2	6	Maidenhead	2	6
Burnley	2	6	Musselburgh	3	1
Bury	3	0	Nuneaton	2	6
Canterbury	2	6	Oxford	2	3
Cheltenham	3	0	Rhyl	2	2
Chester	2	3	Rotherham	2	6
Chesterfield	2	4	Sale	3	0
Coventry	2	6	Shrewsbury	2	6
Darlaston	2	3	Southport	3	0
Droitwitch	2	3	Stratford-on-Avon ...	2	6
Dudley	2	6	Swansea	2	2
Halifax	2	6	Tamworth	3	3
Handsworth	2	6	Twickenham	3	4
Hereford	3	6	Wakefield	2	2
Ipswich	3	0	Warwick	2	6
Kenilworth	2	3	Wednesbury	2	6
Kidderminster	2	4	West Bromwich ...	2	10
Leamington	2	3	Weston-super-Mare ...	2	3
Leicester	3	0	Worcester	2	9
London—E. L. W. ...	3	2	Workington	2	9

Mr. W. B. Bryan, M.Inst.C.E., the Engineer of the East London Water Company, informs us that "the frost has been very erratic, and that the nature of the soil appears to have had far more to do with the depth to which the frost penetrated than the intensity of the frost itself. In one case the main was frozen at 3 ft. 2 ins., and in many other cases of mains not more than 2 ft. in depth not a single case of freezing occurred."

Mr. J. Hall, Assoc.M.Inst.C.E., the Water Engineer of Cheltenham, writes that "the greatest depth to which the frost was found to have penetrated here varied from 2 ft. 9 ins. to 2 ft. 10 ins., but pipes have been burst at over 3 ft., and water mains full of ice have been found at nearly 4 ft. in depth, but there appears to be some reason to account for the action of the frost at greater depths than 2 ft. 9 ins. In all cases the main which has been burst or filled with ice at the extreme depths has, *within a short distance*, been less than 2 ft. from the surface, and I am of opinion that the ice has been formed in the following manner: The water flowing through the pipes has been at, or very closely below, 32°. When at this temperature it would be only just prevented from freezing by being in motion. When the private supply pipes were frozen there would cease to be any demand for water in the pipes. The water would then become stationary, and crystallisation would commence, resulting in the mains being filled with ice."

In nearly all cases the mains which were frozen were under 6 ins. in diameter.

It must be borne in mind that but little snow fell during the period, and consequently the frost was able to penetrate into the ground without check.

Effects on Animal and Vegetable Life.

The intense cold caused great destruction in animal and vegetable life. Rabbits, hares, and game especially suffered, large numbers being frozen, and the remainder being in a great measure only kept alive by artificial food on the moors and fields, and in the farm yards. Deer left the forests in Scotland, and came in herds to the different farm yards, and to the numerous trains which were embedded in the snow, for warmth and food. The spectacle of the seagulls on the Thames will not soon be forgotten—how many were kept alive by food thrown on to the ice, and how many succumbed to cold and starvation.

In the vegetable kingdom there has also been great destruction. Wallflowers, calceolariæ, and roses have especially suffered, and in many places have been completely destroyed. A great many of the hardy shrubs, such as the Portugal laurel and euonymus, have perished, and even those which have not died have been greatly injured. The evergreen oaks, so common in the south of the United Kingdom, have lost their leaves, a circumstance which only occurs in the severest frost.

Comparison with previous Frosts.

With the view of comparing the late frost with those of previous years, we have compiled Table IV., which shows for London and its neighbourhood the number of times in each month of every winter from 1786 to 1895, the maximum temperature was 32° or below, 25° or below, and the lowest reading; and also the number of times the minimum temperature was 20° or below, 10° or below, and the lowest reading. The values given in this table have been extracted from—

1. (1786-1807) Bent's *Meteorological Journals*, Paternoster Row.
2. (1808-1813) Howard's *Climate of London*, Plaistow and Stratford.
3. (1814-1895) *Greenwich Observations.*

For the purposes of this paper we have considered the winter months to be November, December, January, February, and March.

On examining the table it will be seen that in no single month throughout the whole period have there been so many minima readings of 20° or below as in February 1895, the nearest approach being in February 1855 and in January 1881, when there were 10 such instances; but in each of these cases there were no minima of 10° or below, whilst in February 1895 there were two such readings.

On looking at the number of times the maximum was 32° or below, it will be seen that February 1895, when there were 11 such readings, has been exceeded several times, viz. January 1795, 21; January 1813, 15; January 1814, 25; February 1814, 14; January 1820, 13; January 1822,

TABLE IV.—NUMBER OF DAYS, IN THE NEIGHBOURHOOD OF LONDON, WITH THE MAXIMUM TEMPERATURE 32° OR BELOW 25° OR BELOW, AND THE LOWEST READING; ALSO THE MINIMUM TEMPERATURE 20° OR BELOW, 10° OR BELOW, AND THE LOWEST READING, IN EACH WINTER FROM 1786 TO 1895.

Winters.	Maximum. 32° or below.	Maximum. 25° or below.	Maximum. Lowest.	Minimum. 20° or below.	Minimum. 10° or below.	Minimum. Lowest.
1786–7.			°			°
December	2	..	30·0	..	..	..
1788–9.						
November	1	..	31·5	..	..	..
December	11	..	25·5	..	..	..
January..	11	..	26·0	..	..	..
1791–2.						
December	2	..	30·5	..	..	..
January..	4	..	27·5	1	..	20·0
February	1	..	27·5	1	..	17·5
1793–4.						
January	3	..	29·0	..	..	..
1794–5.						
December	2	..	30·5	..	..	..
January..	21	5	21·5	5	..	12·0
February	3	..	27·5	..	..	..
1795–6.						
November	1	.	31·0	..	..	..
March ..	1	..	32·0	..	..	..
1796–7.						
November	1	..	31·0	..	..	..
December	5	1	19·5	1	..	11·5
January..	2	..	29·0	..	..	..
1798–9.						
December	5	3	19·5	3	..	17·5
January..	2	..	29·5	..	..	..
February	6	..	28·0	..	..	..
1799–1800.						
December	6	..	26·0	..	..	..
January..	1	..	27·5	..	..	..
1801–2.						
November	1	..	30·5	..	..	..
December	2	..	32·0	..	..	..
January..	6	..	28·5	1	..	19·0
1802–3.						
January..	9	1	25·0	..	..	..
1803–4.						
December	2	..	31·5	..	..	..
1804–5.						
December	4	..	30·0	..	..	..
January..	3	..	31·0	..	..	..
1805–6.						
December	2	..	29·5	..	..	..
1806–7.						
January..	1	..	31·0	..	..	..
February	1	..	31·0	..	..	..
1807–8.						
December	3	..	25·5	..	..	..
January..	2	..	27·0	2	..	12·0
February	3	..	29·0	2	..	17·0
March ..	..	..	..	1	..	18·0
1808–9.						
December	6	..	30·0	1	..	14·0
January..	6	..	28·0	3	..	18·0
1809–10.	9					
January..	1	..	28·0	5	1	10·0
February		..	32·0	2	..	11·0

Winters.	Maximum. 32° or below.	Maximum. 25° or below.	Maximum. Lowest.	Minimum. 20° or below.	Minimum. 10° or below.	Minimum. Lowest.
1810–1.			°			°
December	1	..	32·0	..	..	..
January...	11	..	27·0	6	..	14·0
1811–2.						
December	4	..	30·0	..	..	..
1812–3.						
December	1	..	32·0	1	..	18·0
January..	15	1	23·0	1	..	20·0
1813–4.						
December	4	..	30·0	1	..	19·0
January..	25	8	21·0	8	..	16·0
February	14	1	23·0	4	..	14·5
March ..	6	..	31·0	..	..	..
1814–5.						
November	1	..	31·0	..	..	..
December	1	..	31·0	..	..	..
January..	9	..	26·0	2	..	15·0
1815–6.						
December	1	..	30·0	..	..	..
January	1	..	31·0	1	..	19·0
February	3	..	25·5	5	2	6·0
1816–7.						
November	2	..	27·0	..	..	..
December	3	1	24·0	1	..	19·0
January..	2	..	29·0	..	..	..
1817–8.						
December	8	..	29·0	..	..	..
January	1	..	30·5	..	..	..
February	5	..	29·5	..	..	..
1818–9.						
December	4	..	30·0	2	..	19·0
1819–20.						
December	6	..	29·0	1	..	13·5
January	13	..	26·5	9	1	4·0
February	1	..	32·0	1	..	19·5
1820–1.						
December	6	..	27·0	..	..	..
January	5	..	27·0	..	..	..
February	.	..	..	1	..	19·0
1822–3.						
December	5	..	28·0	3	..	18·0
January	18	3	19·0	5	2	8·5
1824–5.						
February	1	..	32·0	..	..	..
1825–6.						
January	8	..	26·0	7	1	9·0
1826–7.						
January	8	..	26·5	4	..	15·0
February	5	..	28·5	4	..	15·0
1827–8.						
January	2	..	31·0	..	..	..
February	2	..	32·0	..	..	..
1828–9.						
November	..	..	..	1	..	20·0
January	10	2	24·0	5	..	17·5
February	1	..	32·0	2	..	17·0

TABLE IV.—Number of Days in the neighbourhood of London with the Maximum Temperature 32° or below, 25° or below, and the lowest reading; also the Minimum Temperature 20° or below, 10° or below, and the lowest reading, in each Winter from 1786 to 1895 *Continued.*

Winters.	Maximum. 32° or below.	Maximum. 25° or below.	Maximum. Lowest.	Minimum. 20° or below.	Minimum. 10° or below.	Minimum. Lowest.
1829–30.			°			°
November	1	..	30·5	1	..	19·5
December	11	..	26·0	2	..	16·0
January	8	2	23·0	4	..	12·0
February	6	4	19·0	7	..	13·0
1830–1.						
December	4	2	22·0	4	..	11·0
January	1	..	31·0	2	..	20·0
1831–2.						
January	4	..	31·0	..	..	..
February	1	..	32·0	..	..	..
1832–3.						
January	2	..	31·0	1	..	20·0
1834–5.						
January	5	..	26·0	1	..	17·0
1835–6.						
February	..	..	..	1	..	20·0
1836–7.						
December	4	..	30·8	..	..	..
March ..	..	..	..	1	..	19·5
1837–8.						
November	..	..	..	1	..	20·0
January..	18	7	17·0	8	1	3·0
1838–9.						
January..	1	..	32·0	1	..	19·5
March ..	..	..	..	2	..	19·3
1839–40.						
January..	2	..	26·0	3	..	15·0
February	1	..	32·0	..	..	..
1840–1.						
December	9	..	26·0	6	..	16·2
January	3	2	16·7	4	2	4·0
February	8	..	25·1	3	..	12·4
1841–2.						
January..	3	..	28·0	..	..	..
1842–3.						
February	2	..	26·1	..	..	..
1843–4.						
January..	..	..	..	1	..	18·8
February	2	..	30 9	1	..	20·0
1844–5.						
December	6	..	28·2	..	..	..
February	3	..	29·3	2	1	7·7
March ..	4	1	24·8	2	..	13·1
1846–7.						
December	8	..	27·5	4	..	18·0
January	1	..	29·4	..	..	..
February	2	..	29·6	5	..	11·2
March ..	..	..	..	1	..	16·9
1847–8.						
January	4	..	30·2	1	..	16·8
1848–9.						
January..	2	..	28·0	1	..	19·9
1849–50.						
November	1	..	29·7	..	..	..
December	..	..	..	1	..	18·8
January..	6	..	26·9	..	..	..
March ..	..	..	..	1	..	20·0

Winters.	Maximum. 32° or below.	Maximum. 25° or below.	Maximum. Lowest.	Minimum. 20° or below.	Minimum. 10° or below.	Minimum. Lowest.
1853–4.			°			°
December	2	..	31·5	2	..	18·0
January	2	..	29·8	2	..	13·5
1854–5.						
January..	6	..	27·5	2	..	16·2
February	9	..	29·4	10	..	11·1
1855–6.						
December	4	2	23·2	2	..	16·9
1856–7.						
November	..	..	..	1	..	19·4
December	2	..	31·2	1	..	18·5
January..	..	..	..	1	..	20·0
February	1	..	31·6	1	..	20·0
1857–8.						
January..	2	..	29·0	..	..	..
1858–9.						
November	1	..	30·5	..	..	..
1859–60.						
December	6	..	28·0	4	..	14·0
1860–1.						
December	4	..	28·2	3	2	8·0
January..	5	..	29·7	5	..	16·0
1861–2.						
November	1	..	31·5	..	..	..
January..	4	..	28·4	..	..	..
1863–4.						
January..	3	..	28·1	2	..	14·3
February	1	..	31·5	..	..	..
1864–5.						
December	1	..	30·5	2	..	17·3
January	1	..	29·4	3	..	19·6
February	3	..	28·5	1	..	15·5
1866–7.						
January	12	2	21·2	7	2	6·6
1867–8.						
December	2	..	30·8	..	..	..
January	4	..	30·0	..	..	..
1868–9.						
January..	1	..	32·0	..	..	..
1869–70.						
December	2	..	30·0	..	..	..
January..	..	..	..	1	..	19·6
February	6	..	27·7	1	..	19·4
1870–1.						
December	7	..	26·3	5	1	9·8
January	3	..	27·2	2	..	18·3
February	1	..	31·5	..	..	..
1871–2.						
December	1	..	28·7	1	..	18·6
1872–3.						
February	1	..	31·9	..	..	..
1873–4.						
December	2	..	28·7	..	..	..
February	1	..	30·9	..	..	..
1874–5.						
December	5	1	24·5	4	..	18·5
January..	..	..	..	1	..	18·2

TABLE IV.—NUMBER OF DAYS IN THE NEIGHBOURHOOD OF LONDON WITH THE MAXIMUM TEMPERATURE 32° OR BELOW, 25° OR BELOW, AND THE LOWEST READINGS; ALSO THE MINIMUM TEMPERATURE 20° OR BELOW, 10° OR BELOW, AND THE LOWEST READING IN EACH WINTER FROM 1786 TO 1895—*Continued.*

Winters.	Maximum.			Minimum.		
	32° or below.	25° or below.	Lowest.	20° or below.	10° or below.	Lowest.
1875–6.			°			°
December	2	..	31·0	..	..	..
January..	1	..	27·6	2	..	17·4
February	1	..	28·9	..	..	..
1878–9.						
December	8	..	27·4	3	..	12·2
January..	8	..	26·1	1	..	19·4
February	1	..	30·4	..	..	..
1879–80.						
December	6	..	28·5	5	..	13·7
January ..	4	..	27·1	5	..	17·2
1880–1.						
January..	12	2	24·6	10	..	12·7
1882–3.						
December	2	..	29·1	..	..	..
1884–5.						
January...	1	..	31·9	..	..	..
1885–6.						
January..	1	..	29·0	1	..	16·5
February	2	..	31·2	..	..	..
1886–7.						
December	2	..	28·8	3	..	17·3
January..	3	..	26·0	3	..	15·5
February	..	..	..	1	..	19·7
1887–8.						
November	1	..	29·2	..	..	..
December	1	..	32·0	..	..	..
February	3	..	29·7	3	..	18·4
1888–9.			°			°
January..	2	..	29·5	1	..	19·8
February	..	..	..	2	..	18·9
March ..	..	..	..	1	..	18·7
1889–90.						
December	1	..	31·7	..	..	..
March ..	..	..	..	1	..	13·1
1890–1.						
November	2	..	26·9	1	..	18·3
December	16	1	23·7	6	..	13·4
January..	9	1	24·4	3	..	12·0
1891–2.						
December	3	..	26·2	3	..	17·3
January..	2	..	31·4	..	..	..
February	..	..	..	1	..	18·8
1892–3.						
December	2	..	28·8	1	..	17·6
January..	7	..	26·3	5	..	13·9
1893–4.						
January..	5	2	19·0	5	..	12·8
1894–5.						
January..	6	..	28·7	..	..	..
February	11	..	27·0	11	2	6·9

18; January 1838, 18; January 1867, 12; January 1881, 12; and December 1890, 16.

The combination of such a large number of low maxima and minima temperatures makes the month of February 1895 unique, so far as London is concerned, since 1786. The long continuance of the frost, combined with its severity, points to the conclusion that during the last 110 years the winter of 1894-5 has only been exceeded by those of 1813-4 and 1794-5; and it is within the bounds of possibility, when we consider the imperfection of the thermometers of those early times, and the fact that registering instruments had been but recently invented, and were by no means common, that the winter of 1894-5 may even have exceeded in severity the two winters just mentioned.

In conclusion, we have to express our thanks to all those gentlemen who have kindly favoured us with information, and also to the members of the staff in the Society's office for assistance in working up the data.

DISCUSSION.

Mr. H. Southall expressed his appreciation of the careful manner in which the facts had been marshalled by the authors of the paper. He gave various particulars concerning the thickness of the ice on the river Wye at Ross, during some of the severe winters from 1789 to the present year, and said that in the winter of 1814 snow fell to a very great depth, covering the hedges, and by alternate freezing and thawing the surface became so hard that people walked over hedges for miles. This cold period was known in Ross as the "twelve weeks' frost," but, as was the case in the recent frost, there was a break of one week of mild weather. The cold period in the winter of 1813-4 commenced on December 26th, and terminated on March 19th, a period of 84 days, whilst in the frost of 1894-5, out of 88 nights, ending March 19th, on 77 there was frost registered, the mean temperature of the whole period being only slightly in excess of that recorded in 1813-4. The effects of the recent frost on vegetation did not appear to have been so disastrous as in some preceding periods of severe cold.

Mr. C. L. Prince said that the temperatures recorded at his observatory at Crowborough, in Sussex, 774 feet above mean sea level, were the warmest in the county during the frost. The lowest minimum in the screen was 12°·8, and on the grass 5°·8, and at no other time did the thermometer in the screen fall below 14°. The mean temperature of February was 27°·4, and was the lowest in any month during the 52 years over which his register extended; December 1890, with a mean of 28°·4, being the next lowest, these two months being the only instances of a mean temperature below 30°. At Buxtead Park, 5 miles south from Crowborough, and 150 feet only above sea level, the lowest temperature registered during the recent frost was — 4°; and at Tunbridge Wells, which was 7 miles distant from Crowborough in a north-easterly direction, the thermometer in the screen registered 4°, while an exposed thermometer read — 1°, and one on the ground — 13°·2. From the morning of January 20th, 1838, a temperature below zero had not been recorded in Sussex (except on the temperature of radiation from grass or snow) until February 1895.

Mr. P. Bicknell said that 44 days had been given as the number on which skating was allowed at Regent's Park, but in the grounds of the Toxopholite Society, where the London Skating Club met, skating was continuous for 50 days, and the ice was 11 inches thick. At Swavesey Fen, his son measured the ice and found it to be 2 feet thick.

Mr. C. L. Prince remarked that at East Grinstead the ice was 13½ inches thick, a loaded four-in-hand had been driven at a trot round and round Hedgecourt Lake to the extent of about a couple of miles, and not the slightest fracture was occasioned.

Mr. G. J. Symons said that the burst water-pipes appeared to be the effect of the lack of snow covering on the ground, as the quantity of snow which fell was insignificant and practically useless for the purpose of protecting the soil from the inroads of the frost. The water, too, that was distributed into the mains was almost at a temperature of 32°, and it was hardly to be wondered at that it speedily froze. It would be interesting if some physicist would state whether water under pressure froze at the same temperature as water not under pressure, and what influence motion had on the process of freezing.

Mr. M. Jackson said that the minimum temperatures at Tonbridge, where he resided, occurred on February 7th and 8th, the readings being — 6°·0 and — 6°·5. It would be interesting to ascertain the cause of these periods of severe cold.

Mr. C. Harding said that it was hardly correct to define the recent frost as extending from December 30th to March 5th, seeing that there was a week of mild weather in January, when the temperature was much above the average. It appeared to be desirable to arrive at some decision as to what should be considered as a frost. Concerning the question of the freezing of water in the pipes, it was well known that if water is kept perfectly still, its temperature can be as low as 14° or 15°; but when stirred it immediately becomes ice, and the temperature rises to 32°. It was stated in the paper that the recent frost was the only one in which the number of days in the month of February on which the minimum temperature was below 20° exceeded ten; but in a table printed in his paper on the frost of 1890-1 the period of January 10th to February 25th, 1855 was shown to have had 12 days with a minimum of 10° and less.

Mr. W. H. Dines said that he had never before seen the common furze damaged by frost as it had been this year. With reference to the freezing of water under pressure, increased pressure lowered the freezing point, but to so slight an extent that it could in no way influence the bursting of water mains. He could not agree with the authors in ascribing the high death-rate of March to the frost. In the first place the death-rate was below the average for the first five weeks of the cold weather; secondly, it reached its maximum some time after the thaw commenced; and, the most important point of all, it occurred in conjunction with an influenza epidemic, and was due chiefly to the diseases which always accompany influenza, a similar mortality having occurred from the same cause in the extremely mild winter of 1889-90, and again in May 1891.

Mr. W. B. Tripp inquired whether the cold strong wind which blew on the evening of Sunday, February 10th, would have been likely to produce any effect in reducing the ground temperature, as the water supply in the neighbourhood of Isleworth, where he resided, ceased after that date.

SOME HINTS ON PHOTOGRAPHING CLOUDS.

By BIRT ACRES, F.R.Met.Soc.

[Received March 28th.—Read April 17th, 1895.]

The increasing interest that is being taken in the form, movement, and measurement of clouds, and the undoubted superiority of photography as a recorder of these phenomena, must be my excuse for describing my own experiences of cloud photography. I shall not discuss the formation of clouds, but only give a few hints as to the best manner of securing successful photographs of the different kinds, although I must confess to an inclination to expatiate on the beauty and grandeur of the subject.

One of the greatest charms of this much abused climate may be found in the fantastic forms, the subtleties of colour, and the delicacy of light and shade, that follow each other in rapid succession during unsettled weather, particularly in spring and early summer.

Fortunately, a study of the clouds does not involve expensive journeys, as the dweller in town has almost equal opportunities with his more fortunate confrère in the open country ; even in the centre of smoky London the most magnificent skyscapes are often met with—the very presence of smoke, soot, and dust adding gorgeously ruddy tints which otherwise would be absent. To the observer in the heart of London, of course, the view is limited ; but even in the most densely populated places there is ample room for observation and enjoyment ; but to appreciate the beauties of cloud and sky to the full, it is necessary to reach some open space (such as the Thames Embankment or the bridges, for instance) in order that the forms and colours near the horizon may be seen.

It is true that photography cannot reproduce the glorious colours seen in nature, but with proper care and skill, and the choice of suitable apparatus,

it may be made to render truthfully in monochrome the most delicate forms and brilliant effects of light and shade. The successful photographing of clouds is so entirely different from the ordinary run of photographic work, that very few photographers succeed in producing even passable results—except so far as sunset (sometimes called moonlight) effects are concerned, which are comparatively easy by reason of the enormous contrasts of light and shadow which obtain under such conditions. The principal difficulty lies in the difference between the visual intensity of colours and their action on a photographic plate. It is quite unnecessary for me to state that when a ray of white light is decomposed by a prism, a band of colours is produced, ranging from red (the least refrangible ray) through orange, yellow, green, blue, and violet, the latter being the most refrangible ray.

The most luminous colours are yellow and orange, but if we were to expose an ordinary commercial photographic plate to this band of colours we should find that these bright colours, yellow and orange, had produced no effect whatever on the plate, but that all the photographic action had taken place in the blue and violet bands, colours which to the eye appear quite dark, so that such a photograph would render blue and violet as nearly white, whilst all the other colours would appear of one uniform blackness.

If instead of an ordinary plate we use one that has been corrected for colour, that is, by the use of certain colouring matters made sensitive to the luminous rays, yellow, orange, &c., and expose it to the same spectrum band, we find that the yellow band comes out as light as blue, and green comes out much lighter than was the case with the ordinary plate. Now, by the use of suitable colour screens, we may cut off, or reduce in intensity, any desired part of the spectrum; and as in this case we wish to introduce the colours of the spectrum in their correct monochromatic value, we find it necessary to restrain the action of the blue and violet, and so must interpose a pure yellow screen. A green screen is not suitable for photographic work, except when it is desired to photograph greens and blues only, as the action of green is to absorb red and orange, and so lower their intensity. Pure yellow permits red, orange, yellow, and green to pass without loss; the blue and violet being alone cut off.

Let us apply these facts to the photographing of sky and clouds. We see delicate clouds faintly illuminated against a blue sky, but still to the eye the blue of the sky looks many tones darker than the cloud; yet, in consequence of the great photographic activity of blue, a photograph taken on an ordinary plate, in the usual way, fails to give the white cloud its proper luminous value. But if we employ a plate corrected for colour, and interpose a pale yellow screen between the sensitive plate and the sky, it will be found, on developing the plate, that the proper value of the cloud against the darker blue sky has been recorded.

There are many cases where a screen is not required, such, for instance, when it is desired to photograph brilliantly luminous cumuli against an intensely dark blue sky; then, by giving a suitable exposure, the values may often be correctly photographed even with an ordinary plate.

Apparatus.—I have found a magazine hand camera, holding a dozen plates of 4¼ in. × 3¼ in. size, most convenient for cloud work. I keep it always charged ready, so that if any special cloud formation presents itself, I am able to secure that without difficulty. Another advantage of the camera held in the hand, is that it can be rapidly pointed to different parts of the sky, or a series of exposures can be made at only a few seconds interval of the same mass of cloud, &c. I make a rule, however, to always work with a lens of one focus for each size camera; thus my lens for 4¼ in. × 3¼ in. size plate is 6 inches focus, and my lens for 12 in. × 10 in. camera is 18 inches. My object in doing this is so that I can always ascertain the angular measurements of clouds, whereas if I used lenses of various foci, it would necessitate marking the negative with the focus of the lens, and consequently comparisons between one negative and another would not be so easy as at present.

A lens of the rectilinear type will be found the most useful, stopped down according to the rapidity of the plate, the intensity of the light, and the depth of colour of screen (if any) employed. It is not possible to give even an approximate idea of correct exposure, as I have sometimes given an exposure of one-thousandth part of a second and secured good results, when only white streaks on blue had to be dealt with; and in other cases I have given several seconds to secure a delicate cirrus cloud, employing a Nicol prism.

Plates.—I prefer for general cloud work plates that are known commercially as "Isochromatic," and the rapidity that I have found most useful is the "medium rapidity."

Exposure and Development.—I have just said that it is not possible to give any idea of correct exposure, but I want to insist on the necessity of *full* exposure. I know that I am not in accord with most workers in recommending this; but experience has taught me that with a good moderately slow plate better results are obtained by fully exposing the plate and developing with judgment, than can possibly be obtained by aiming at a mathematically correct exposure.

I make it a rule always to back the plates, that is to coat the glass side with some substance that will absorb any light that may pass through the film, as unless this be done the light that passes through the film will be reflected by the under surface of the glass back to the film, and produce a blurred definition—technically known as "halation." The amount of blur being dependent on the strength and contrast of the lights and shadows, I usually employ for this purpose bitumen dissolved in benzene, which, in addition to being very effective in absorbing light, has the advantage of drying very rapidly, so that the plate can at once be placed in the dark slide. Further, the vapour of benzene does not produce any deleterious effect on the sensitive plate. *In no case* should any compound be used which contains turpentine, as the vapour of turpentine will cause the plate to become hopelessly fogged; and as this vapour has an affinity for wood, the dark slide will be rendered useless, unless it is carefully coated with an alcoholic solution of shellac, or is

placed in the open air for a week or so. Bates's black, which may be obtained from any dealer in photographic material, is a convenient form of backing, and in cases where it is intended to expose the plate immediately, burnt sienna ground in water, which may be obtained at any oil shop, is most effective. This latter backing possesses the advantage of being easily removed with a wet sponge before developing the plate; but it will not produce any deleterious effect if it is left on the plate during development. To remove the bitumen or Bates's black, use a little benzene on a sponge. It is only necessary to remove enough of the backing to enable the opacity of the negative to be judged by transmitted light, the final cleaning of the plate may be left until after it has been washed and dried.

If it is desired to coat plates with burnt sienna for use at some future time, it is advisable to add a little gum arabic and glycerine to prevent the pigment drying up and powdering off, thus producing dust in the dark slide, which would cause myriads of pin holes in the finished negative. A preparation of caramel has been recommended for backing plates; but I have found bitumen or burnt sienna thoroughly satisfactory.

As it is of the utmost importance that none of the material used for backing should get on to the surface of the film, the easiest way is to lay the plate face downwards in the dark slide and then carefully paint the back with a camel's hair brush, if bitumen is used, or a moistened sponge or piece of clean rag if burnt sienna is used. When a plate is backed a much more prolonged exposure may be given than is permissible with an unbacked plate.

DEVELOPMENT.—Before commencing to develop a plate see that the dark room light is safe, that is to say, if you are using a plate sensitive to yellow and orange, the medium through which the light is filtered, be it glass or fabric, should be as nearly *pure* red as possible. Ruby glass cannot be relied upon for the purpose. I have examined large quantities of ruby glass with the spectroscope, and I have invariably found that it lets through a large quantity of yellow and green light, to say nothing of orange. The best medium that I have come across is the geranium red paper sold by dealers in photographic materials. If ordinary plates are used, two thicknesses of "canary medium" will answer well with artificial light—daylight is too uncertain to be used for the source of illumination of the dark room.

Proceeding to develop the plate, I first prepare in addition to the normal developer a second developer strongly restrained with bromide, the quantity of extra bromide depending largely on the class of negatives to be developed.

The normal developer I mix as follows:—

Pyrogallic Acid	2 grains
Liq. Ammonia ·889 ...	2 min.
Potassium Bromide ...	One or two drops of a 10 % solution
Water	1 oz.

To make the restrained developer, I double the quantities of pyrogallic acid and ammonia, and add from 15 to 30 drops of the 10 % solution of

potassium bromide. In addition to this I keep handy a 10 % solution of potassium bromide in a dropping bottle.

I now proceed to flood the plate with the normal developer, and closely watch the result: if the image comes up steadily and correctly, I do not make any modification; but if it rushes up and the plate begins to blacken all over, I quickly pour this developer away and, without stopping to rinse the plate, pour on the restrained developer, and let it act until the image as seen by transmitted light has gained vigour. If the image then appears too strong in contrast, I rinse the plate well and allow it to remain in water for a short time, or apply a fresh solution of the normal developer without any bromide, according to the appearance of the plate. But usually allowing the plate to remain in clean water is the most effective method, as the film generally holds sufficient developer to enable the plate to gain more detail; and there is less risk of getting the image too opaque, as is often the case when fresh strong developer is used after a highly restrained one. When the image does not show up at its proper time after applying the normal developer, I usually dilute the developer with water according to circumstances, in some cases putting ten times as much water as developer. In this way I have sometimes been able to save a plate that seemed hopelessly under-exposed.

In developing negatives of brilliantly lighted cumulus clouds, the greatest care must be taken to prevent the image becoming too opaque, particularly if a colour sensitive plate and a yellow screen have been employed; otherwise in the resulting photograph the blue of the sky will appear quite black, whilst the delicate half tones in the higher lights will be lost. For such subjects it is better to dilute the normal developer with two or three times its bulk of water. Going to the opposite extreme, in developing a negative of the delicate cirrus clouds, it is often desirable to commence with the highly restrained developer previously mentioned, otherwise it is difficult to produce any contrast between the clouds and the sky, even when a colour sensitive plate and a yellow screen have been used.

Screens.—It is necessary to point out that ordinary pieces of glass are not suitable for colour screens—the glass must be optically worked with surfaces absolutely parallel to each other.

Nicol Prism.—So far I have only treated of photographing clouds by means of colour sensitive plates and suitable screens, but I have found these to fail sometimes when trying to photograph some of the almost invisible cirrus clouds; and as I had been impressed with the curious phenomena that are presented to the eye when the sky is examined through a Nicol prism, I have used such a prism with the lens. Briefly described, the effect which takes place is this: when the Nicol prism is pointed to the sky and revolved slowly round, it will be found that in some positions the blue sky light is much reduced in intensity—in fact appears to change colour; but any clouds that may be in the field of view are not affected in this way—the light from them is not quenched, hence they appear to stand out brilliantly white against the dark sky. More careful observation of the position in which the Nicol prism most effectively quenches the sky light will show that the

maximum effect takes place when the prism is held so that its longer diagonal is at right angles to an imaginary line drawn from the sun to the part of the sky examined; that is, if the prism is pointed to a part of the sky at the same elevation as the sun, but to left or right of it, the maximum effect of cutting off sky light takes place when the longer diagonal is perpendicular. But if a part of the sky above or below the sun is examined, then the maximum effect is found when the longer diagonal of the prism is held horizontally; intermediate points between these would necessitate it being held in the same relative position to the sun. This phenomenon is most marked when a part of the sky at right angles to the sun is examined. Having noted this effect, I naturally turned it to account in photographing clouds, and was rewarded by obtaining some remarkable results. It is hardly necessary to state that the reason the Nicol prism cuts off the sky light in some positions is that the light is polarised. If ordinary unpolarised light be examined, no difference will be found in whatever position the Nicol prism is held. This accounts for the fact that the clouds stand out brilliantly when the sky light is cut off. The light from the cloud is not polarised, hence it passes freely through the prism in any direction.

I have omitted to mention that a useful piece of apparatus is a perfectly plain optically worked black glass mirror, set in front of the lens. This seems to perform two functions, partly acting as an analyser, cutting off the polarised light of the sky, and partly as an absorbent, the blue sky light seeming to be more absorbed than the white light from the clouds.

DISCUSSION.

Capt. D. Wilson-Barker, in a note to the Secretary, said:—"Mr. Birt Acres' paper is an extremely interesting one from the pictorial and photographic side of the cloud question, although I must take exception to some of his remarks on the formation of clouds. No remarks can add to the use of the polarising appliance for cloud photography after the beautiful pictures he has shown on the screen to prove this point. I should, however, like to point out that I was using screens as early as 1887, placed at the back of the lens. The screens were formed by exceedingly thin films of mica, which can be obtained of almost any colour and transparency. Mine were specially prepared for me through the kindness of Mr. Wiggins, the well-known mica merchant, and the results obtained by using these screens on the upper clouds, using the ordinary plates, was a decided improvement on working without the screens. My custom is to use a small stop and instantaneous exposure, $\frac{1}{10}$ of a second or thereabouts, and develop slowly with an iron developer. In the case of the cirrus and other thin clouds, it is almost impossible to tell when the plate is exactly developed, and a certain amount of guessing, corrected of course by experience, is necessary when removing from the developer. Printing under green glass often improves the results. I quite agree that a hand camera is the best for obtaining cloud snap shots, as it can be used instantly and pointed anywhere to the sky without trouble."

THE MOTION OF CLOUDS CONSIDERED WITH REFERENCE TO THEIR MODE OF FORMATION.

By W. N. SHAW, M.A., F.R.S.

A Lecture delivered before the Royal Meteorological Society, March 20th, 1895.

The invitation to take up the responsible position which I hold to-night has placed me in a situation of great embarrassment. The only reason which could in any way justify my accepting the invitation amounts to this, that the science of Meteorology may be regarded as the Physics of the Earth's atmosphere, and (from circumstances over which I have had very little control) one of my daily duties is to expound the elementary principles of Physics to a succession of members of the rising generation.

My embarrassment arises from two sources. First, that in undertaking to deal with the application of Physics to Meteorology, I am allowing myself to face the facts of nature in some of their most perplexing and difficult forms. Now as teachers of Physics we are accustomed to arrange subjects in such a way that we can manage them. We simplify the conditions until we can deal with the facts. We have an authority for doing so which is very high and very much respected. The greatest of ancient philosophers in giving directions for instructing the youth in Astronomy (a kindred study), writes in the seventh book of the *Republic*:—"And do you not think that the genuine astronomer will view with the same feelings the motion of the stars? That is to say, will he not regard the heaven itself, and the bodies which it contains, as framed by the heavenly architect with the utmost beauty of which such works are susceptible? But as to the proportion which the day bears to the night, both to the month, the month to the year, and the other stars to the sun and moon, and to one another,—will he not, think you, look down upon the man who believes such corporeal and visible objects to be changeless and exempt from all perturbations; and will he not hold it absurd to bestow extraordinary pains on the endeavour to apprehend their true condition? Hence we shall pursue astronomy with the help of problems, just as we pursue geometry; but we shall let the heavenly bodies alone, if it be our design to become really acquainted with astronomy, and by that means to convert the natural intelligence of the soul from a useless into a useful possession."

Such is Plato's idea of the proper method of teaching astronomy. We teach the principles of Meteorology after a method not dissimilar. Throughout history, for the purpose of teaching Physics, Nature has been, if not

conventionalised, at least limited by careful selection of the facts. But the facts of your science laugh at the limitations which the physicist would like to impose, and I find myself suddenly confronted with your real atmosphere, with its moisture, its dust, its warming and its cooling, its electricity, and I know not what besides (far different from the ideal atmosphere of a laboratory or a lecture room). You will, I hope, be tolerant if the result is merely cloud or fog.

Secondly, I have in my daily routine the advantage of addressing an audience not less ignorant of the subject matter than myself. To-night the relations are reversed, and I have, unfortunately for myself and for you, to address, from the point of view of ignorance, an audience of experts. It is too late now to withdraw or alter, but may I take the liberty to suggest that if you should on any future occasion be kind enough to ask the co-operation of a mere pedagogue in Physics like myself, you should ask him not to give a lecture which must infallibly betray his own ignorance, but to set an examination paper in the subject. I feel certain that it would be easy to ask some questions which you would all regard as interesting, and while you wrote the answers, I should have no difficulty in sitting here to see that no one copied; if the answers were good enough to deserve full marks, they would do more for the development of your science than I could do in a lifetime of lecturing.

The department of your subject to which I wish to call your attention is the motion of clouds, and in particular the consideration of the question whether the motion of the cloud really indicates the motion of the air in which the cloud is formed. The question is an important one, for so much of our information about what is going on in the upper strata of the atmosphere depends upon observations of cloud and cloud motion. It arises, so far as I am concerned, from some *dilettante* attempts to deduce the motion of air masses from the shapes of clouds, and if possible to picture the conditions of motion. To illustrate my meaning, I will take the liberty of putting before you some specific instances in which the motion of air seems not properly indicated by the clouds. The most conspicuous and typical is the case of the mountain cloud-cap. There is, I suppose, nothing in nature which looks so absolutely peaceful and at rest as the cloud which surrounds a mountain top on a bright summer day. But in the cloud itself there is quite another state of things. No one who has experienced it need be reminded that the apparent rest is really compatible with a strong, cold, unpleasant wind carrying the fog with it, apparently, so long as you are close enough to see separate parts. The cloud-cap really defines a locality where cloud is formed in the wind as it travels past the top; a little beyond the top the cloud disappears.

I have sometimes noticed phenomena in the case of ordinary fog which I put into the same class. I will not inflict upon you a photograph of a fog, but merely mention a particular observation. In a thick fog, lasting a whole day of last winter, in Cambridge, I had occasion to pass and repass certain streets in the course of the day. There were certain localities all

included within a half mile on the same level in which the fog was always conspicuously lighter than elsewhere. The motion of a fog is no doubt very slow, but I do not think it is entirely absent, and I regard those localities as positions in which the fog thinned from evaporation while the air passed over them. But I cannot explain why it should do so, any more than I can explain the limits set to the cloud-cap.

The third instance is a cloud that grew from a small cumulus into a thunder cloud. It has, I believe, frequently been observed that thunder clouds come up against the wind. I have heard the apparent motion attributed to an upper current of air. I regard it myself not as a moving of the cloud either against the wind or with an opposing upper current, but as the formation of fresh clouds in positions successively more and more to windward. On the screen is a photograph of a cloud that developed itself above a village in the Gulf of Genoa in a somewhat peculiar manner. It started as an ordinary cumulus above the hill at the back of the village, and grew out as a long horizontal strip of cloud. Here the cloud had a growing point like a plant, but did not move as a whole. It developed in a few hours into a thunder cloud, and ultimately disappeared with a thunderstorm.

The fourth example is shown in a group of cumulus clouds. It is well known that a cumulus cloud is the cap of a rising column of vapour-laden air, and the lower surface of the cumulus marks the height at which condensation begins. But the ascent of air in one part corresponds to its descent in other parts, and consequently the question one naturally asks one's self on seeing a cumulus is: "Where is the air coming down?" In most cases it is difficult to give an answer. Take for instance a sky full of small cumulus clouds. It would appear necessary that the spaces between the cumulus clouds should be occupied by descending air, and the air circulation that is in progress in such a sky must be a very complicated one; but the only motion apparent is the steady horizontal progression of the cumulus clouds across the sky, which gives but a faint impression of the real motion. I once watched such a sky form on a bright morning above the narrow neck of land that forms the St. Ives promontory in Cornwall; the cumulus clouds travelled with a North wind, and formed initially over the land alone. It was difficult not to attribute the initial formation to the sun's heat on the narrow strip of land, but the clouds persisted as they travelled out to seaward in the south, and eventually the sky became overcast. In this case vertical motion was clearly indicated by the shape and grouping of the clouds, whatever may have been the horizontal motion.

On the other hand, I have endeavoured on some occasions to measure the rate of travel of cloud shadows, hoping thereby to deduce the velocity of the upper strata of air. The most suitable occasion is generally when a North-west wind is driving the scud of a cyclone across bright sunshine. My measurements have been very rough, and have generally come out about 40 miles an hour. This seemed so reasonable and satisfactory, that it was difficult to think that one had not some definite air-motion indicated by the observed motion of the clouds. Of course vertical motion

would not be specifically indicated, but it would probably be small compared with the rapid horizontal motion, and its neglect would not be serious.

We may get a little light thrown upon the subject by considering for a moment the artificial clouds formed by the discharge of steam and smoke from chimnies. An observer, unacquainted with the habits of locomotives, who measured the velocity of a distant but well-marked cloud of familiar shape, and supposed he had measured the velocity of air, would be clearly wrong; he would really have measured the velocity of the funnel of the locomotive. That may be actually what one measures in the case of cumulus. On the other hand, a smoke puff emitted from a stationary chimney moves with the wind (making a small allowance for the effect of gravity), and the same is true of steam if one is near enough to see the motion of the separate puffs of steam, but not otherwise. To sum up this part of my subject, we may say that, although a motion of cloud does indicate part, in some cases nearly the whole, of the truth as regards air motion, in others the visible cloud boundaries show merely the limits of position in which condensation is taking place or disappearing, and the change of these positions is not necessarily an indication of the motion of the air in which these clouds are formed.

Let us then proceed to examine the causes of the formation of cloud, and see whether they will throw such light upon the subject as will enable us to distinguish between the cases.

There are two recognised causes of formation of cloud.

I. The mixing of two currents of different temperatures.

II. The so-called dynamical cooling of air by diminishing the pressure.

It is assumed by many writers that clouds are formed by the mingling of currents moving in opposite or different directions at different altitudes. Now I will not, in the presence of so many meteorologists, deny the possibility of such a state of things, but I will merely ask in what direction you would expect a cloud so formed to move? Suppose, for example, the currents to be north and south respectively: will the cloud formed by mixing move north or south, or east or west? The cloud would surely be formed in the "no man's land" between the two prevailing currents, and its motion would be entirely misleading if regarded as an indication of the motion of either. We should not therefore expect to get indications of air motion from observations of clouds in such a case. The real fact is that conditions would have to be very peculiar for such an arrangement to take place. Probably most of the meteorological phenomena we observe take place in the stratum intermediate between the streams of prevailing air currents. In such a case as that indicated above there would be what might be called discontinuity in the motion of the air at successive levels; and though a cloud might fairly be supposed to move for some distance with its air, it is difficult to say what inference could be drawn from any particular observation.

Another example of the formation of cloud when there is discontinuity of motion is given by ground fogs. They arise, I suppose, in two cases :—

I. When cold air passes over a warm moist region, either a pond or moist ground; and these are strictly analogous to the steam formation over a pan of hot water. The fog is then localised by the representative of the pan, and belongs to the cloud-cap class of clouds. Fragments of cloud may move with the air, but such fragments often disappear rapidly, and the whole cloud viewed from a distance would appear stationary.

II. When warm moist air passes over a cold surface.

This case is illustrated by the fog, which I understand is apt to surround icebergs. Here again the cloud is localised by the iceberg or its equivalent, and is apparently stationary. It belongs again to the cloud-cap class.

I can, however, imagine a case in which mixing might take place when the motion of cloud would indicate the motion of air, provided I may assume that the vertical motion is a very important element in defining the direction of air currents, in the regions between the centres of the rising and falling streams; and I should like to show you how very easily vertical motion is produced in air. The smallest difference of temperature is sufficient to cause a change of density which gives rise to vertical motion. [This was shown by means of a paper spiral suspended by a silk fibre.] Let us consider what would happen to the air over an area strongly heated by the sun's rays; we should have a sort of chimney with air coming in all round the base. Such an arrangement may be the one which in reality occurs when a cyclone is formed, the air supplying the currents at the base will be drawn from warm moist regions in the south or west, and from cold dry regions in the north or east. Where they meet they will not probably ascend vertically, as in the case of an ordinary chimney, but be wrapped up together in spiral streams. Where cold and warm currents are side by side, cloud will be formed by the mingling of the streams of air. At the boundary of this region, where the cold air is beginning to predominate there may be detached clouds travelling with the spiral motion and fairly indicating the motion of the air; such motion will be nearly horizontal if the area of the cyclone is large. It is perhaps carrying speculation too far to suggest that the scud which comes with the North-west wind at the tail of a cyclone marks the limiting position of the mixing of the warm Southerly current with the cold Northerly one; but I believe that the explanation of the phenomenon may be found in that direction. It does not seem impossible to work out a consistent and satisfactory theory of the origin and motion of cyclones by regarding them as moveable chimnies of vast width and height, but not necessarily in every case having their bases at the ground level. There is not time this evening to dwell longer upon the subject. I will, however, show an experiment on the formation of cloud by the mixing of air currents, and ask you whether you think you can detect the motion of the air by watching the movement of the cloud.

A glass globe (Fig. 1) provides the arena in which the currents mix. The currents are due to the heat of a spirit lamp or gas jet, burning at the base of a chimney which communicates with the top of the globe. On either side of the globe are tubular openings through which air can flow to feed the

chimney. The air supply on the one side is warmed and moistened, on the other it is cooled by a freezing mixture. The apparatus can be so arranged that no cloud is formed with either one of the currents acting singly, but when both act together a conspicuous cloud is formed extending up to the

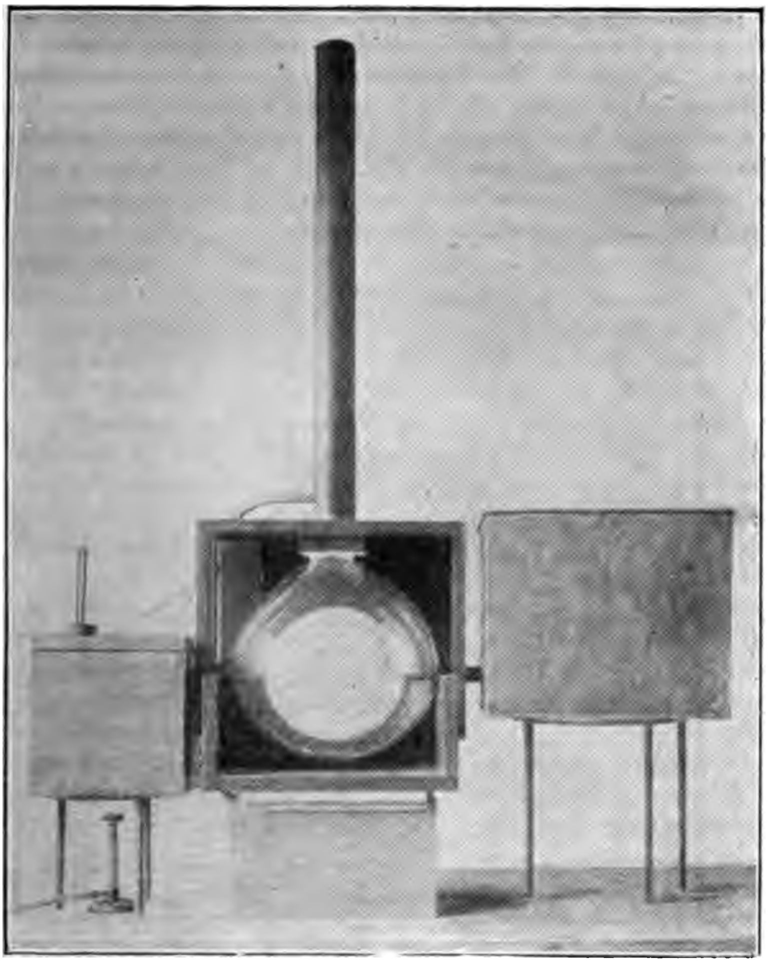


FIG. 1.

chimney, and showing by the motion of its parts the direction in which the air is moving. The spiral motion, which is clearly visible, is attributable to the fact that the tubes which deliver the air are more or less parallel, but not diametrically opposed to one another.

Let us now consider the second cause of cloud formation. The cloud in this case arises from so-called dynamical cooling of the air. [To produce

the cooling all that is required is to allow the air to expand and overcome the external pressure while protecting it from all communication of heat. The arrangement is sufficiently nearly realised when air rises into regions of diminished pressure in consequence of its density being less than that of the surrounding air. The small density may have been originally due to rise of temperature. The amount of the cooling effect in dry air produced under such circumstances is very well known, and, indeed, is quite easily calculated on the assumption that the laws of perfect gases are accurately followed.

The way in which the effect can be for many purposes most satisfactorily represented is by a diagram (Fig. 2). The black lines in the diagram represent the relation between pressure and volume for one gramme of dry air at various temperatures marked on the edge. The red lines (shown as dotted lines in the figure) represent the changes that take place in pressure and volume when there is no communication of heat.

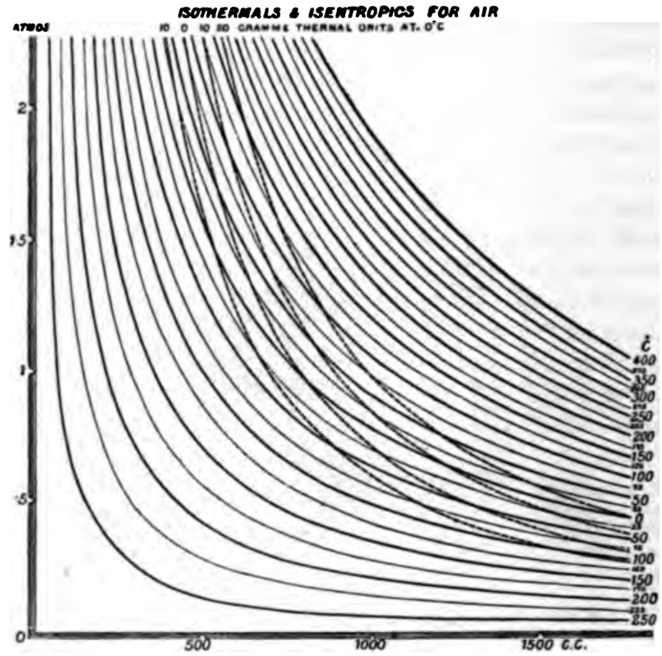


Fig. 2.

To pass from one black line to the next on the right, 10 gramme thermal units of heat must be communicated to the gramme of air at the freezing point; and here I must parenthetically remark that it would be well for those who wish to lay hold of this part of the subject to get rid of the very natural notion that change of temperature is a necessary concomitant of supply or removal of heat. Doubtless in many cases the two are connected, but progress in thermo-dynamics is facilitated by recognising that the tem-

perature may change without any supply of heat, and heat may be supplied without any change of temperature. A small addition to the diagram makes it available for showing the change of temperature which results from the raising of dry air to a specified height from sea level.

But the atmosphere does not consist of dry air; it contains a variable amount of moisture. So long as the air is unsaturated, its behaviour under diminution or increase of pressure does not differ materially from that of dry air, and the diagram we have already considered may be used to indicate the changes of temperature. But when the cooling is so great that the dew point is reached, a serious modification is introduced. The condensation liberates the latent heat of vapour, which is numerically very great, so that although the amount of water condensed may be very minute, the disturbance of the thermal conditions is by no means unimportant. An example will make this clear. The cooling of saturated air from 15° C. (59° F.) to the freezing point would correspond to the deposition of 8 grammes of moisture from every cubic metre, or 8 millionths of a gramme (a very small amount) from every cubic centimetre. The heat liberated by the condensation would be about 48 ten-thousandths of a thermal unit; but the capacity for heat of a cubic centimetre of dry air is very small, only 2¼ thousandths of a thermal unit being required to raise the temperature of that quantity of air 1° C., so that the heat liberated by the condensation is sufficient to raise the temperature of the air from which it is condensed through about 20° C. In other words, to put the result in a somewhat Hibernian form, if saturated air were dynamically cooled from 15° C. to 0° C., its temperature would rise to 20° C., in consequence of the condensation of vapour.

Of course all that is meant by this absurd statement is that if you subject saturated air to a change of pressure which would cool dry air through 15° C., the moist air will not be cooled to anything like the same extent.

Leaving for the present the theory of the subject, I shall try to show you by experiment the difference of behaviour of air under the conditions specified.

First, let me show the formation of a cloud by dynamical cooling—that is, by rarefaction merely—in moderately dry air. I have here (see Fig. 4, p. 180) an arrangement by which the pressure of air in a globe can be rapidly diminished by putting it into communication with a vessel which has been partially exhausted. I can thereby ascertain what would happen to the air if it should be suddenly raised through 5,000, 10,000 or 15,000 ft. You will, I think, see that a cloud can be formed in that way.

Let me now go on to exhibit, if possible, the difference between the temperature change produced in dry and moist air. A slight addition to the apparatus enables us to form a rough estimate of the depression of temperature below that of the room at the instant when the expansion is complete. At that instant I close the communication between the exhausting vessel and h experimental globe with its cooled air. At the same time I put the globe in communication with a pressure gauge, and watch the change of pressure which occurs as the air in the globe recovers the temperature of the room.

We will try the experiment with dry air. You will notice that after the serious disturbance of the gauge, as the expansion proceeds, there ensues a gradual increase of pressure which indicates the change of temperature. This is the well-known experiment of Clément and Desormes. By making experiments successively with a globe of dry air and a globe of saturated air, the rise of temperature could be roughly compared in the two cases; but in order to avoid part, at least, of the initial disturbance, I propose to exhaust the two globes simultaneously (Fig. 3), and have one limb of the gauge in connection with each globe. With the apparatus so arranged, the ultimate difference of level of the liquid in the two limbs of the gauge will indicate the difference of temperature which existed in the two globes at the instant when the expansion was complete. With a water gauge a difference of level of one inch corresponds to a difference of temperature of $1\frac{1}{4}°$ F.

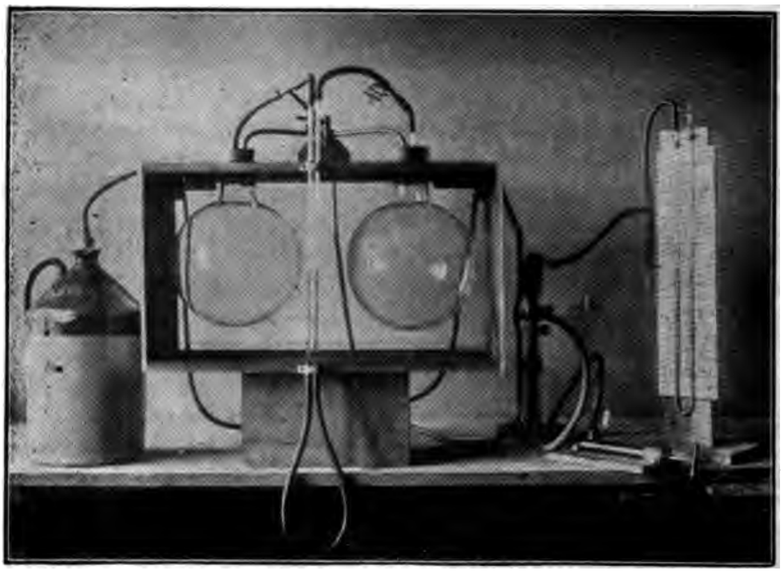


FIG. 3.

In this experiment the expansion is small, and the temperature difference may be scarcely perceptible. I shall be content if it is shown by any difference of level in the gauge. I ought to remark that the saturation of the air introduces a slight modification of the figures, and gives moist air an advantage on the gauge which ought to be eliminated before the method could be recommended as an accurate one for scientific purposes.

The effect of condensation in modifying the dynamical cooling of moist air depends very materially upon the position of the dew point of the air, because with a high dew point the amount of moisture condensed, per degree of depression of temperature, is much larger than the corresponding amount

condensed when the dew point is low; for example, the amount of condensation from saturated air corresponding to a depression of 5° C. from 30° C. is 7·1 grammes per cubic metre; but from 5° C. to 0° C. it is only 2·1 grammes per cubic metre.

The behaviour of moist air could be represented by a set of lines corresponding to those which I have shown you for dry air, but the lines would be of different shape. A diagram which represents the behaviour of moist air was constructed by the late Dr. Hertz, so well known in connexion with electrical waves. It is somewhat too complicated for this evening. It may suffice to give the results of some rough calculations in connexion with this part of the subject. I have computed that a change of pressure sufficient to cause a dynamical change of temperature in dry air of 27° F. would not depress the temperature of saturated air at 41° F. through more than 18° F., nor saturated air at 86° F. through more than 6° F.

I hope to find time later on to call your attention to the meteorological effects which these modifications of dynamical cooling probably produce; but in order to follow the main thread of my argument with respect to clouds I must pass on to consider the suspension of solid and liquid particles in the air.

I will again form a cloud, and I wish you to notice closely what happens in the globe. As soon as the cloud is formed, the drops begin to fall. Some of them, doubtless, become invisible in consequence of the evaporation of the moisture; but if the disappearance were entirely due to the communication of heat through the glass of the globe, the last traces of cloud would appear at the centre or in the upper part of the globe. That, however, is not the case; there is clearly a falling of the particles going on. We may therefore conclude that when a cloud is formed in still air, the particles of which the cloud consists fall through the air at an appreciable rate. The rate is different in the two globes before you, because probably the size of the water particles is different. The smaller globe has been supplied in great abundance with nuclei upon which drops can form, while in the larger one nuclei are comparatively rare, and consequently to carry the deposit each nucleus must be more heavily loaded.

If there were a suitable upward motion of the air, the particles forming the cloud might appear stationary—there would still be relative motion between the water particles and the air. No refinement of subdivision can free the particles from the ubiquitous and inevitable action of gravity; and so long as the particles have a specific gravity greater than that of air, they can only be maintained at a fixed level by the action of forces due to the air passing by them. [Speaking in the technical language of dynamics, the particles can only be maintained at a fixed level by supplying to them an amount of momentum equal to that which gravity constantly supplies, but in the opposite direction. The momentum is withdrawn from the stock which the rising column of air possesses, and a condition for the transference of the necessary momentum is relative vertical motion between the cloud particles and the supporting air. In every case, therefore, when a cloud is supported there is a vertical rush of air past the particles of it which keeps them up.]

The amount of relative motion which is necessary to support the partic[illegible] depends upon their weights and areas, and therefore, of course, upon th[illegible] size, and the uprush of air must increase rapidly if the particles are co[illegible]tinually growing in size.

From another aspect these ideas may be expressed by considering a ra[illegible] drop or hailstone supposed to form in still air. It will begin to move dow[illegible]wards however small it may be, but its downward velocity will never excee[illegible] definite limiting value depending upon its size and weight. What the lim[illegible]ing velocity of falling raindrops may be I do not know, but from the rate which the drops of a thunder shower fall we may fairly conclude that a v[illegible] considerable, though by no means inconceivable, upward current of [illegible] would be required to keep the drops of a thunder shower suspended at a fi[illegible] level. Clearly a smaller current would suffice to keep up winter rain[illegible] Scotch mist, and ordinary ground fog is so finely distributed that the verti[illegible] motion necessary to support it is hardly, if at all, perceptible.

All that has been said on this point must be understood to refer to verti[illegible] motion only. So far as horizontal motion is concerned, when a cloud particles has once accommodated itself to the motion of the air carrying there will be no relative motion unless the air changes its speed, so that [illegible] horizontal motion of air may be indicated by the horizontal motion of cl[illegible] while the vertical motion is not.

Let us now consider the case of a mass of warm, moderately moist starting from the earth's surface and gradually rising. With increasing hei[illegible] the pressure and density will diminish; the temperature will fall, rapidly[illegible] first, as the diagram indicates, until it reaches the dew point. Then a cl[illegible] will be formed, and the rate of fall of temperature will be much diminish[illegible] The condensed particles will gradually sink, and at the same time [illegible] upper strata will receive heat from the sun's rays which are there absorb[illegible] The upper layers will be ready to go on rising, and as they are satura[illegible] with moisture cloud will be formed at higher and higher levels, and th[illegible] unless the initial difference of density was very great, we may have eq[illegible]librium very nearly approached, and the mass may move very slowly [illegible]ward, carrying with it the greater part of a very light and almost perman[illegible] cloud. In the mean time the heavier globules of the moisture deposited[illegible] the earlier stages will have fallen downward, and may be evaporated lo[illegible] down, or fall as rain. Perhaps the air may even be regarded as lik[illegible] rocket, moving upward and leaving a trail of cloud globules behind it, [illegible] may, after becoming transparent again for a time, ultimately show itself[illegible] some form of cirrus cloud.

I must, however, here recall to your memories the now well-known [illegible] that for a cloud to be formed two conditions must be satisfied—there m[illegible] be not only a supply of vapour to be condensed, but also a supply of nu[illegible] (formed of particles of dust, &c.), upon which the drops of rain may[illegible] deposited. This part of the subject almost belongs to Mr. John Aitk[illegible] who has founded upon the principles of it a method of counting the [illegible] particles in the air. Now although it is not possible by lifting the air to [illegible]

haust the whole supply of vapour, the supply of nuclei may be exhausted, and then, unless the air carries with it globules already condensed, deposition will no longer take place, and the air will pass upward free from cloud, but "supersaturated" with moisture. I use the term because it has been used before, but the necessity for the existence of nuclei, in order that deposits may be formed, points to a vagueness in the meaning of the word 'saturated' that requires clearing up. Nuclei may not all be of the same character, and the condensation may take place at first upon nuclei of one sort only. When they have been loaded and have dropped out, further rarefaction may cause another set of nuclei to come into use. It would be interesting to know what depression of temperature is necessary to cause condensation upon nuclei of different characters, and what relation the temperatures at which condensation takes place bear to the ordinary dew point. These questions carry me, however, beyond my own knowledge and experience: I must limit myself to showing, later on, some experiments in connexion with the formation of coloured coronæ that I think indicate a change in the character of the deposit with a change in the number or character of the nuclei.[1]

Let me, however, now take up the consideration of the meteorological effects of the liberation of latent heat when condensation takes place. I propose to take only the two extreme cases, (1), when the air is very cold; (2), when it is very warm. The cooling in the first case is considerable even when condensation takes place, because the actual amount of moisture condensed for a given fall of temperature is, comparatively speaking, small. The rising air will therefore sooner reach a position of equilibrium. A cloud may be formed, but no further rise need result; the deposit is thin, and the rain, if any, is fine. In the second case the deposit of moisture for a given range of temperature is many times larger. The fall of temperature incidental to expansion is very much less. Hence, as the warm air rises it remains warm in consequence of the condensation of a part of its vapour, and becomes surrounded by air, higher, and therefore, presumably, colder than that which surrounded it originally. Having risen to a certain height, its tendency to rise becomes still greater; it is further away from a condition of equilibrium than it was when it started. The higher it rises, the greater will be the force tending to make it rise. The result will be an uprush of air which may be described as almost explosive in its character.

To this difference we may attribute the suddenness and violence of the thunder showers of summer as compared with the fineness of the rain of winter. Explosive uprushes, such as those here referred to, have long been recognised as furnishing an explanation of the formation of hail. If we were acquainted with the electrical effect of air rushing past globules of water—a state of things that must occur if the globules are to be supported—we might

[1] Mr. C. T. R. Wilson, at a meeting of the Cam. Phil. Soc., in May 1895, showed experiments tending to prove that whatever is the state of the air as regards nuclei, the rarefaction cannot be carried beyond a certain definite limit without cloud being formed. The limit is not beyond that of practical meteorological altitudes.

reach a tolerable explanation of most of the characteristic phenomena of thunderstorms.

I shall now, by way of summary, sketch what seems to me the probable state of motion of the air in which cumulus cloud is forming, and in some of the other instances quoted above.

As already intimated, cumulus cloud is indicative of an upward motion of air. Its base shows the position at which condensation commences, the upward motion being sufficient to retain the globules suspended, and possibly carry some of them further upward. A spreading of the base of the cloud indicates only that the area of the "chimney" is altering or its position changing. It does not necessarily imply any specific horizontal motion of the air. In the example of the large cumulus over the Gulf of Genoa: if we suppose warm, moist air to be gradually drifting in from sea towards the hills, successive portions more and more to seaward would bulge upwards, and there would be a spreading seaward of the conditions favourable to cloud formation, in a direction, that is to say, opposite to that of the wind.

It is not easy to picture the conditions which define the upper surface of a cumulus cloud. It is, I think, most probable that the cumulus should be regarded as the same in nature as a cloud-cap, the air running more or less vertically through it. After the first formation of cloud on the rising air, further elevation would cause an increase in the size of the drops; but as the size increased the power of the air to carry them with it would diminish. Ultimately it would have to leave its droplets behind, and pass on clear but saturated with moisture. The process would free it of the nuclei upon which the drops formed, and this suggests a definite limit to the cloud surface. The sun's rays would necessarily introduce some modification, and make the surface lower and the cloud consequently of less thickness. It must, I think, be accepted that the sun cannot alter the temperature of the air which holds the cloud. Heat is only taken in from the sun's rays in any appreciable quantity so long as there are water globules; they will be surrounded by saturated air. The heat absorbed under these conditions evaporates the moisture without alteration of temperature. As soon as the moisture is all evaporated, the air has become transparent, and the rays pass on to give out heat elsewhere. The evaporation caused by the sun will, however, enable the air to carry with it some of its nuclei.

It therefore would appear that the air issuing from the top or sides of the cloud leaves behind it its larger globules of moisture, and therefore nearly all the nuclei in which moisture was first deposited. If condensation again occurs, and a fresh cloud is formed in the same air, it must be under different conditions, *i.e.* with a different set of nuclei.

When the sky is full of patches of detached cumulus, the vertical circulation is less simple. A layer of warm air of considerable horizontal area must come, on its upward way, into a state of instability when condensation begins to take place. The condensation in any small portion puts that portion in a more favourable condition for further ascent than the surrounding portions in consequence of the liberation of latent heat. Some

allowance must be made for the alteration of density consequent upon the contraction of volume which takes place when condensation occurs; but this allowance is not large, and, moreover, when the air finds the drops of water heavy to carry, it leaves them behind. As soon, therefore, as condensation takes place at any point, there is an upward rush there, associated with a sinking of air around; hence the clouds form themselves permanently round the spots where condensation begins, extending or disappearing according to circumstances, which can at present only be regarded as accidental. The elaborate vertical circulation here sketched may be associated with a general horizontal motion of the air due to some dominant cause external to the whole district.

In a subject like that here treated, general conclusions are particularly hazardous; but there seems to be some ground for concluding that when clouds are formed by mixture their motion may be accepted as indicating that of the air in which they are formed, but that when they are formed by the dynamical cooling due to rarefaction, no satisfactory indication of the motion of the air is given by the motion of the clouds.

In the course of my remarks I have referred to possible effects of an alteration in the number or character of the nuclei upon which the globules of moisture are formed. It now only remains for me to illustrate experimentally the effects alluded to. If the globe (Fig. 4) in which a cloud is formed by a sufficient rarefaction is illuminated by means of a brilliant point of light, coloured rings are shown surrounding the bright point, provided that the air is in a suitable state. The condition for the formation of coronæ, as explained by Young, is that the globules formed should be sufficiently uniform in size to produce regular diffraction, and Young has also pointed out that the diameter of a ring of particular colour depends upon the size of the particles, becoming smaller if the globules of which the cloud is formed become larger. Experimentally, the diffraction rings are easily watched if the globe be surrounded by a blackened screen perforated by a hole, and an electric lamp be brought close up to the hole, and a cloud be then formed in the globe. The necessary rarefaction can easily be produced by opening free communication between the globe and an exhausted receiver of suitable size. If the globe be fully supplied with nuclei in one of the ways suggested by Aitken, as by allowing the smoke of a match to pass into it, the rarefaction produces cloud without definite colouring, probably because the nuclei are so numerous and irregular that no regular diffraction takes place. After a number of rarefactions and consequent precipitations, a circular distribution of colour begins to show itself round the bright spot. The colours change as the cloud grows in density, and after many deposits have been made, a series of alternate red and green rings (with artificial light) of measurable radius becomes perfectly distinct, while the globules become large enough to be separately visible, and can be seen settling down in the globe. The size of the rings under these circumstances becomes

moderately permanent for successive rarefactions, and would enable the observer to compute the size of the particles if there were a standard of reference available with particles of known size. I have not yet, however, succeeded in imitating the effects with other particles, nor can I say what

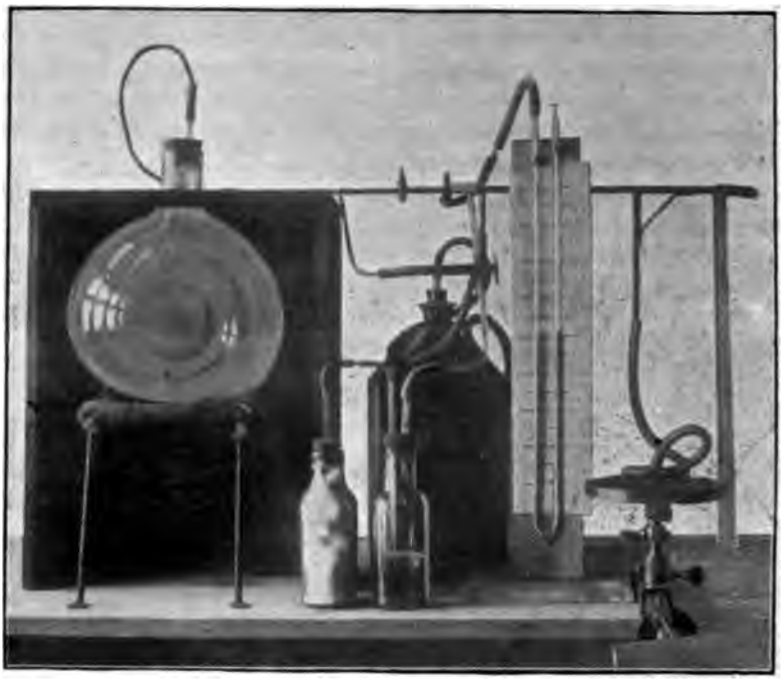


FIG. 4

the change in the character of the nuclei must be, nor what rarefaction with air of given humidity is necessary to give rings of a particular diameter. These matters are, however, within the reach of an experimenter in this subject.

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

March 20th, 1895.

Ordinary Meeting.

C. THEODORE WILLIAMS, M.A., M.D., Vice-President, in the Chair.

HECTOR HATCH GAMMELL, Perry Barr, Birmingham ;
CHRISTOPHER LLOYD, 1 Invicta Villas, Balmoral Road, New Brompton ; and
Lt.-Col. WILLIAM WOODWARD RAWES, R.A., Junior United Service Club, S.W.,
were balloted for and duly elected Fellows of the Society.

Mr. W. N. SHAW, M.A., F.R.S., gave a Lecture on "THE MOTION OF CLOUDS CONSIDERED WITH REFERENCE TO THEIR MODE OF FORMATION," which was illustrated by experiments. (p. 166.)

April 17th, 1895.

Ordinary Meeting.

RICHARD INWARDS, F.R.A.S., President, in the Chair.

Capt. PERCIVAL ASHWORTH, R.E., Shorncliffe Camp;
JOHN CHAPMAN, The Lawn, Torquay;
EDWIN J. PEARSON, J.P., Millfield, Berkhamsted;
STANLEY SINGLE, Woodcote, Dorking;
Capt. EDWARD RICHARD TAYLOR, Ardgillan, Balbriggan, Ireland; and
C. ALGERNON WHITMORE, M.P., 75 Cadogan Place, S.W.,
were balloted for and duly elected Fellows of the Society.

The following communications were read:—

"THE FROST OF JANUARY AND FEBRUARY, 1895, OVER THE BRITISH ISLES." By FRANCIS CAMPBELL BAYARD, LL.M., F.R.Met.Soc., and WILLIAM MARRIOTT, F.R.Met.Soc. (p. 141.)

"SOME HINTS ON PHOTOGRAPHING CLOUDS." By BIRT ACRES, F.R.Met.Soc (p. 160.)

CORRESPONDENCE AND NOTES.

Notes on Clouds.—I began registering clouds in 1842, and have kept this up to the present time, and have many thousand records, which I intend to reduce if I have health. My relative (Luke Howard) first persuaded me to pay attention to clouds; and I think I was the first to adopt the term "scud," which I did in 1843. At that time I invented signs for clouds; and almost immediately afterwards a code of signs were sent to me that, though independent, were almost identical. I had the following columns for each observation:—Height (0 — 6); Velocity (0 — 6); Thickness (0 — 6); Colour (0 — 6); Direction (0 — 6); Class At the same time was recorded "prospect." I think you use the word "visibility." When at Highfield House, Beeston, near Nottingham, I recorded the following:—1. Charnwood Forest, 27 miles off, and according to clearness registered 0 — 6; 2. Beeston Railway Station, 2 miles; 3. The Lake, Highfield House, ½ mile; 4. The sunk fence of the garden, 100 yards; and 5. A yew tree, 40 yards.

Since I came here I have selected as my objects Dunkerry Beacon, Steep Holmes, Cheddar, Clevedon, Denny Island, Caldicot, Caractea's tree, far end of the park 500 yards, and this end of the park 50 yards off. I must remark that mists here are never as much as 20 yards, whilst at Highfield House they were so great that the prospect was sometimes only 2 yards.

I have never seen it recorded that cirri do not move along their lines; they grow at their ends. I have also never seen it mentioned that there are movements *inter se* different to the currents they are moving in. Nor have I seen it recorded that in thunderstorms there will be scud boiling from beneath them, often in the opposite direction to their movement.

Here we can see clouds at great distances, as our uninterrupted view from west through south to east is 172 miles. We are also often above the clouds, and can look along their edge. I reported a case where a cirrus formed above a stratus, and both at a lower level than this house. On another occasion I recorded cirri forming directly above the stratus that lay over the Bristol Channel when the sky was elsewhere cloudless, and this occurred on February

8th and 9th, 1895. The water must have been very cold, as the Wye at Chepstow was frozen, though tidal. The stratus and cirri were only over the water, as the Somerset hills were quite clear.

Sometimes we see marvellous clouds. On one occasion since I have been here we had a dense fog all day, with overcast sky, but for a few minutes there was an oblong opening in the mist, through which we could see the steep Holme and Dunkerry Beacon, nearly 40 miles off. The fog must have been confined to this hill.—E. J. Lowe, F.R.S., Shirenewton Hall, Chepstow, March 13th, 1895.

The Upper Atmosphere.—On July 7th, 1894, Dr. Assmann set free at Charlottenburg a balloon, equipped with self-registering apparatus for the determination of meteorological data in the higher regions of the atmosphere. This balloon, the *Cirrus*, made a most remarkable voyage, for not only did it reach the greatest altitude ever attained by any contrivance made by human hands, but it also in eleven hours made a journey from Berlin to the district of Zvornik in Bosnia, a distance of more than 620 miles. The scheme of exploring the upper air by means of small balloons was first proposed by Geheimrat A. Meydenbaur, and put into practice in France; but these attempts failed because no measures were taken to guard against the powerful effects of solar radiation on the instruments. This was rendered possible by the aspiration principle applied by Dr. Assmann, and, after many trials, a camera largely composed of aluminium was constructed by R. Fuess, in which an alcohol thermometer and the lever of a barograph could be photographed through a slit on to a silver-bromide gelatine paper stretched on a drum. On the morning of the 7th the *Cirrus* was released, shot up "like a champagne cork," sailed first towards the north-west, and at a greater height turned round towards the south-east, finally coming to earth in Bosnia, close to the Servian frontier. The meteorologist Berson, who went to fetch the balloon, was only able with all possible haste to reach the spot in fifty-four hours, while the balloon had made the journey in twelve hours. The apparatus was hardly injured at all; and the photogram, unrolled ten days later, showed clearly the pressure and temperature of the regions traversed by the balloon. When the balloon rose the pressure was 30 ins., and the temperature of the air 62°·6. Both naturally diminished with the height, the pressure to 3·35 ins. and the temperature to —61°·6. Here the record breaks off, for the paper was not large enough, such low pressures not having been expected. According to a careful calculation, the height then attained must have been 53,559 feet, or not much less than twice that of Mount Everest, the highest mountain of the world. Evidently the balloon had ascended still higher, but its highest point could not be recorded. Besides, the registering apparatus was arranged for six hours only. It is to be altered so as to record lower pressures and to act for twelve hours.

Studies of the Upper Air.—Mr A. L. Rotch recently read a paper before the Boston Scientific Society, U.S., on this subject, in which he described the methods employed for obtaining a knowledge of the movements, etc., of the upper air, and mentioned some of the results which had been attained. Man has seldom penetrated into the stratum above 4 miles, and of course the rarefaction of the air, whose pressure at a height of 10 miles is less than one-ninth of the pressure at sea-level, is the chief obstacle to its exploration by beings like ourselves. Twice during the past 33 years men have reached a height of about 30,000 feet in balloons; they have climbed in the Himalayas to an altitude of nearly 23,000 feet, and, in each case, have observed the temperature and pressure during the few minutes they remained at these altitudes. Quite recently, instruments to record automatically these and other elements have been placed on the summit of a quiescent volcano in Peru, above 19,000 feet, from which it is hoped to obtain fairly continuous records. Latterly, also, other attempts in France and Germany have been made to gain information as to the temperature of still higher strata by liberating small balloons carrying no aeronauts but only self-recording barometers and thermometers. After giving an account of the various high level mountain observatories, and also of the observations of clouds, etc., Mr. Rotch concludes by saying "that observations on mountains are still the only ones capable of being made of all the elements at all times, although clouds can be observed very often, and their systematic study will even-

tually be recognised as necessary for weather forecasting. Occasionally, observations in captive balloons and with kites will furnish reliable data in special cases when it is desired to investigate the conditions prevailing in the free air near the earth, but the necessarily infrequent observations which can be made at high altitudes in balloons carrying aeronauts, or the few automatic records obtained from unmanned balloons, which may reach still greater altitudes, will hardly do more than elucidate the general conditions reigning towards the top of the great aerial ocean."

Height of the Sea Breeze at Toulon.—Two interesting voyages were made in a balloon at Toulon on October 16th and 18th, 1893. On the 16th, MM. Louis Godard and Jacques Courty ascended from Toulon at 11.20 a.m., and were carried by a South-south-west wind towards Fort Faron. But at a height of about 1,600 feet the balloon began to turn towards the south, and at a height of 3,450 feet its course was due south. After passing the coast at an elevation of 4,690 feet it was carried by a North-easterly wind over the roadstead and the peninsula of Cepet. The aëronauts then descended, and found a South-westerly wind at an altitude of 1,000 feet.

On the second occasion an ascent was made at 4.20 p.m., and an Easterly current was found up to a height of 1,300 feet. At 2,000 feet the balloon was suddenly driven southwards towards the sea, and on descending to 520 feet entered the Easterly current again, and was carried to the Château of La Valerane on the Golfe de Giens.

From these experiences it appears that the land and sea breezes on the coast attain only a moderate height, at most 3,000 feet, and there give place to the general currents of the atmosphere. The limit is subject to constant changes, which must be controlled by the transition from day to night. The influence of the seasons on these breezes has still to be investigated. The change in the direction of the wind occurred at a much lower altitude, 300 to 400 feet, during the balloon experiments at New York in 1887. On October 16th and 18th Toulon lay at the south-eastern edge of an area of maximum pressure, with a fairly uniform pressure and light Easterly winds in the neighbourhood.

Dorset Annual Rainfall.—Mr. H. S. Eaton, a past President of the Royal Meteorological Society, has recently discussed the annual rainfall of the county of Dorset for the 45 years 1848-92, and communicated the results in the form of a paper to the Dorset Natural History and Antiquarian Field Club. Two maps accompany the paper: in one the general distribution of the rainfall is shown by blue shading, and in the other the brown shading is in proportion to the elevation of the land above sea level. From these maps it is seen that the distribution of the rain is in conformity with well known natural laws.

Mr. Eaton says:—"The vapour-laden air from over the warm water of the Atlantic, the chief source of supply, in passing inland from the coast under the prevailing South-west wind, is cooled by expansion in its onward progress over the hills, and discharges rain copiously, especially on their further flanks. A close observer of nature, but not a meteorologist, used to say of the rain on the high ground behind Abbotsbury: 'With a South-west wind the clouds get a blow from the hills, and cry on the other side.' Further on, over the low-lying lands of Somerset, the rainfall is 2 or 3 inches less than on the south coast of Dorset. Omitting the exceptional returns from Portland, Wimborne, and Tudbeer, it will be noticed that between Lyme Regis and Bridport the rainfall is slightly under 34 inches, falling to 30·5 inches round Weymouth, and to 30 inches round Poole. Inland from the coast it rises from 33·4 inches at Bridport to 34·0 inches at Netherbury, which is 125 feet above sea-level and 5¼ miles from the coast, to 39·8 inches at Beaminster, 1½ miles further on at the foot of the hills; and to 42·6 inches at Cheddington, just on the watershed dividing the English from the Bristol Channel, 604 feet above the sea. Thence it declines to 33·8 inches at West Coker, 240 feet above the sea, and to 28·4 inches at Ilchester, only 40 feet above sea-level. Farther east, Abbotsbury and Littlebredy, a ridge of hills about 600 feet high intervening, the rain rises from 30·7 inches to 39·2, being 8·5 inches in less than 3 miles; and between Portisham and Littlebredy, in a distance of 2 miles, it increases 7 inches. Of the two stations of Upwey, that nearest the sea has an annual rainfall of 30·96 inches at

70 feet above sea-level; the other 90 feet above the sea, and ¼ mile nearer Ridgeway Hill, has a rainfall of 33·05 inches. On the chalk hills extending from west to east across Central Dorset, the annual rainfall exceeds 40 inches. Here the county attains generally its highest elevation, from 600 to 800 feet. The highest point in the county, Pilsdon Pen, west of Beaminster, exceeds 900 feet, closely followed by Bulbarrow, near Haselbury Bryan. The hills are nearly as high east and south-east of Shaftesbury; but the clouds in their passage over Central Dorset lost a portion of their burden, and the rainfall in North-east Dorset does not quite attain 40 inches. North of Central Dorset the rain diminishes to 34 inches in Blackmore Vale. In the 5½ miles between Minterne Magna and Folke the diminution is 9·2 inches. Between Haselbury Bryan and Sturminster Newton the rate is still greater, being 15·5 inches in 4¼ miles. At Haselbury Bryan, however, the fall of 49·0 inches may perhaps be increased by insplashing from some flints built round the gauge to support it in position; but the village is only 2½ miles north-west from Bulbarrow, which has an elevation of 903 feet, and 4 miles north-east of Church Hill, 822 feet, and Nettlecombe Tout, 854 feet, and it is the proximity of high ground rather than the actual elevation above sea-level that influences the fall of rain."

Old Rain Records from the Holy Land.—Among the shorter notices in the *Meteorologische Zeitschrift* for April is one by Dr. Hann on extracts from Vogelstein's paper "Agriculture in Palestine at the time of the Misnah," his Doctor's dissertation at Breslau in 1894. This deals with the Agriculture in Palestine during the first two centuries A.D. The Misnah mentions two seasons; the Rains and the Dry Season. The "Former Rain," to use the Biblical phrase, sets in soon after the autumn equinox. Its importance was such that if it was deficient, prayers were at once ordered, and continued drought was marked by a period of public humiliation. The rain was measured with a vessel. In the first rain 3·5 ins. ought to fall. In the second double as much, and in the third treble as much. In the second period the rain should fall for seven days without a break. The "former rain" is at the seed time; the "latter rain" in the month Nisan (March-April) is of the greatest importance for the harvest. Severe thunderstorms with hail occur during the rains. In the dry season rain is very unusual, but dew is very abundant and of the greatest benefit to the crops. The result is that the rain of Palestine in the first century amounted to about 21 inches per annum, a figure which agrees pretty well with modern measurements at Jerusalem.

Meteorological Charts of the Red Sea.—The Meteorological Council have recently issued an Atlas of Monthly Wind and Current Charts of the Red Sea, which have been constructed from observations mainly taken in the ordinary track of vessels passing along the central line of the sea, and the charts consequently only show the average phenomena in that line. A new form of wind rose has been adopted in the preparation of the Wind Charts, which shows not only the frequency of the winds, but also their forces, so that an estimate may be formed of the direction and strength of wind likely to be experienced in any part of the sea.

From October to January the prevailing winds are Northerly over the northern half of the sea, but they are Southerly over the southern part, extending further north in these months than at any other time of the year. From February to May the Northerly winds extend further south, Southerly winds prevailing from Perim to about the 16th parallel; while from June to September Northerly winds blow over nearly the whole sea. Gales, which are most frequent during the winter months from November to March, are encountered chiefly in the southern part of the sea, and generally blow from the Southward.

The Current Charts give the set in each 24 hours, and an examination of the arrows shows that the currents in the Red Sea are somewhat erratic, and that while their velocity is not usually great over large areas, occasionally strong streams, frequently across the line of a ship's track, may be locally experienced. In the Straits of Bab-el-Mandeb direct observations are very deficient, but experience has shown that when the wind is strong from either the Northward or the Southward the current is generally strong in the same direction in the

narrow waters. The currents often set with considerable velocity in the Gulf of Aden.

A feature of some interest has been noticed in the range of sea temperature in the Strait of Bab-el-Mandeb, near the Island of Perim. In this neighbourhood it amounts to 26° at the period of the South-west Monsoon; in September the highest temperature recorded being 92°, and the lowest 66°. A similar difference has been observed in July and August. In June and October the difference in the extreme temperature is 16°, and the least difference, 7°, occurs in February.

Currents of the North Atlantic.—The *Pilot Chart* for June has a map representing the drift in the North Atlantic, as indicated by bottle papers returned to the Hydrographic Office during the last six months, a star marking the spot at which the bottle was thrown overboard, a circle the point at which it was recovered, the line joining them being drawn in a majority of cases as nearly straight as intervening bodies of land would permit, and in the remainder, conforming to some extent with the well-established result of current observations. This chart, taken in conjunction with that of July 1891, published as a supplement to the *Pilot Chart*, indicates a circular movement of the waters of the Atlantic around a point lying to the south-west of the Azores, and coinciding with the anticyclonic region, around which the prevailing winds blow in a similar direction. Starting from a point to the southward of the Grand Banks of Newfoundland, the outer edge of this vast circulating system of waters mounts towards the north-east as far as the 51st parallel of latitude, there becoming easterly. North-west of the Azores, a portion of the current again takes a north-easterly direction, which ultimately lands these bottles upon the coasts of Scotland and Norway. The main body of the drift, crossing the meridian of 20° between 40° and 50° N. latitude, turns to the southward and parallels the shores of Europe and Africa until the latitude of the Canaries is reached, experiencing on its way south a slight deviation towards the Straits of Gibraltar. Quiting then the African coast, the external edge takes a south-westerly direction, unites with the northern portion of the equatorial current, and entering the Gulf of Mexico through the Yucatan passage, emerges as the Gulf Stream by the Straits of Florida.

Although the period of drift for the various bottles covers widely differing intervals and seasons, the results for any one region show a fair degree of accordance.

RECENT PUBLICATIONS.

American Meteorological Journal. January-May 1895. 8vo.

The principal articles are:—Variations in the character of the seasons: by H. Gawthorp (7 pp.).—The cause of the cyclones of the Temperate latitudes: by W. H. Dines (6 pp.). The author discusses the problem of the formation and maintenance of the cyclones of these latitudes, and after examining the theories of Ferrel and Hann, believes that the weight of evidence is decidedly in favour of the former's or the convection theory.—Recent foreign studies of Thunderstorms, V. and VI.: by R. de C. Ward (10 pp.). In these papers the author describes the work done in connection with thunderstorms in Russia and Switzerland during the last few years.—The study of atmospheric currents by the aid of large telescopes, and the effect of such currents on the quality of the seeing: by A. E. Douglass (18 pp.).—The study of atmospheric electricity at sea: by Prof. W. F. Magie (3 pp.).—Periods in Temperature: by Prof. H. A. Hazen (3 pp.).—The cause of cyclones: by Dr. A. Woeikof (3 pp.). This is a criticism of Mr. Dines's paper mentioned above.—Meteorological problems for physical laboratories: by Prof. C. Abbe (4 pp.).—Long range weather forecasts: by Prof. H. A. Hazen (4 pp.).—Topographic influence on the winds of the Weather Maps: by F. B. White (5 pp.).

Ciel et Terre. Revue Populaire d'Astronomie, de Météorologie, et de Physique du Globe. January-June 1895. 8vo.

The principal meteorological articles are:—Fleurs de glace: par W. Prinz (20 pp.). This is illustrated by sketches and photographs showing the formation of rime or hoar frost.—Les grands froids observés en Belgique: par P. Marchal (9 pp.). The lowest temperature recorded in Belgium during the frost of 1894-5 was —26°·7 at Ville de Bois. In Brussels the lowest temperature recorded in any winter was —6°·0 in 1775-6.—La période de froid du 27 janvier au 17 février 1895: par A. Lancaster (8 pp.).

Indian Meteorological Memoirs, being Occasional Discussions and Compilations of Meteorological Data relating to India and the neighbouring Countries. Vols. V.-VI. 4to. 1894.

These contain the following papers:—The diurnal variation of atmospheric conditions in India; being a discussion of the hourly observations recorded at twenty-five stations since 1878. The stations dealt with in parts 4-6 of Vol. V. are Agra, Allahabad, and Lucknow.—The relation between sun-spots and weather as shown by meteorological observations taken on board ships in the Bay of Bengal during the years 1856 to 1879: by W. L. Dallas. The author says that considering that the observations investigated extend over a period embracing only two cycles of the required number of years, and that the number of observations available for the different years varies so largely, the curves appear to afford confirmatory evidence that, side by side with other variations, there exists in certain classes of terrestrial phenomena an eleven-year cycle agreeing to a certain extent with the eleven-year cycle in the solar spots. As opposed to this, there is the fact that, so far as these observations show, there is no connection between the actual number of spots and terrestrial weather.—Investigation into the mean temperature, humidity, and vapour tension conditions of the Arabian Sea and Persian Gulf: by W. L. Dallas.

Instructions to Observers of the India Meteorological Department. By J. Eliot, M.A., F.R.Met.Soc., Meteorological Reporter to the Government of India. 8vo. 108 pp. 1894.

This book is intended to supersede the *Indian Meteorologists' Vade Mecum*, which is out of print. Meteorological observers in India now merely take the readings of certain instruments and forward the observations by telegram or by post to the Meteorological Office. The reduction and preparation of the data for subsequent use and discussion is done in one or other of the Meteorological Offices in India. Hence this book of "Instructions" is confined to a description of the various instruments in use at the meteorological stations in India, the precautions to be taken to maintain them in good order, the methods to be used to restore them to good order when it is possible for the observer to do it, and the proper methods of reading the instruments and of taking and recording the observations.

Kongliga Svenska Vetenskaps Akademiens Handlingar. Band 20. Afd. I. No. 3. 8vo. 1895.

Contains:—Sur la distribution à Vienne et à Thorshavn des éléments météorologiques autour des minima et des maxima barométriques: par P. Akerblom (36 pp.). This is a continuation of an investigation of a similar character published in 1883 by Prof. Hildebrandsson, as regards Upsala only. Dr. Akerblom has chosen Vienna as a continental and Thorshavn as an oceanic station, and has investigated the distribution of each element as regards the position of the observing station with respect to maxima and minima. The paper does not allow of being abstracted for these pages, but it is of interest to find that in several particulars Dr. Akerblom's results confirm those given by the Rev. W. Clement Ley in his paper on "The Relation between the Upper and Under Currents of the Atmosphere around areas of Barometric Depression," which appeared in the *Quarterly Journal Roy. Met. Soc.* Vol. III. (1877), p. 437. One very interesting result comes out from the paper. The observations of M. Richter at Ebersdorf in Silesia have shown that the motion of cirrus in that district are very different from those found to exist both in Sweden and England.

Dr. Akerblom has tested the Silesian results by others from other places in North Germany, and he says that he can arrive at no other conclusion than that in Sweden and England the axes of cyclonic disturbances reach up into the region of cirrus cloud, while in lower latitudes the disturbances have less vertical depth.

Meteorologische Zeitschrift. **Redigirt von Dr. J. Hann und Dr. G. Hellmann. December 1894-April 1895. 4to.**

The principal articles are: Zum 250 jährigen Jubiläum des Barometers: von G. Hellman (6 pp.). This is a *résumé* of the correspondence in Italian which passed between Torricelli and others in the years 1643-44.—Natur und Ursache des Polarlichtes: von A. Paulsen (12 pp.). This is a paper translated from the *Verhandlungen der Konigl. dänischen Akademie der Wissenschaften in Kopenhagen.* Dr. Paulsen, during his stay in Greenland in 1882-3, had copious opportunities of observing aurora. He found that the steady displays did not affect the magnetic needle, while those that moved rapidly did affect it. The curtain displays had the greatest action. The author goes on to show that it is not the electricity which produces the aurora, but that the former is a secondary phenomenon due to the latter. He considers the auroral light to be a phenomenon of fluoresence, produced by the absorption of an energy developing itself by radiation and having its origin in the upper region of the atmosphere. In other words, it is not the arch or the curtain which emits the light, but invisible rays which become luminous by change in the energy.—Der Regenfall auf den Hawaii Inseln: von J. Hann (18 pp.). This is an interesting account of the climate of the Sandwich Islands, based on the observations collected by Mr. C. J. Lyons, Director of the Weather Bureau in Honolulu. Dr. Hann discusses wind and rain. He shows how the Trade wind blows constantly at low levels, and becomes a wet wind as it is forced to ascend, and a dry wind after it passes the cols. If the mountain range is too high for the Trade to get over it, regular land and sea breezes set in on the lee side. The paper contains several rain tables, and gives us more complete information than exists for any other group of islands in the Pacific.—Ueber das Wetterleuchten: von Dr. W. Meinardus (8 pp.). This is an attempt to explain the inaudibility of thunder in the case of sheet lightning by the total reflection of sound waves from air strata of different density superposed on each other. The author cites as a proof of his theory that thunder has been heard in balloon ascents at much greater distances than ever occurs at the surface of the earth. The explanation is the same as that of mirage for waves of light.—Zur Kenntniss des täglichen Ganges der Luftfeuchtigkeit in den Thälern der Centralalpen: von Dr. F. V. Kerner (9 pp.). This is a discussion of observations carried on with Kappe's hair hygrometer for four summers at Trins, in the Gschitz Thal, in the district of the Brenner. The investigation is carried out in great detail as regards the variations in vapour tension and relative humidity with different winds, such as Föhn winds and South-easterly wind.—Temperatur und Feuchtigkeitsbeobachtungen über und auf der Schneedecke des Brockengipfels: von Dr. R. Süring (8 pp.). These observations were carried on through the winter of 1893-4, and give a fuller amount of material of the action of a snow covering than existed elsewhere. The following are the final results:—1. In making such observations no protection from wind can be used, as the differences materially depend on wind force. 2. The difference of temperature between the air and snow surface increases with temperature and with clearness of sky. The differences at the height of 1 cm. are reduced to one half their value. 3. With cloud or snow, the snow surface is usually warmer than the air. This arises from the quicker cooling of the air. 4. The vapour tension and relative humidity of the air is usually greatest immediately above the snow. 5. The conditions for the evaporation of snow are much more favourable than for condensation. The setting in of the latter is generally shown by the occurrence of hoar frost.—Wolken-studien von Clement Ley: von H. Hildebrandsson (9 pp.). This is a review of the first portion of *Cloudland*, and it merits careful study from Dr. Hildebrandsson's eminence as one of the highest authorities on and most diligent students of clouds. He points out that Mr. Ley's altitudes differ considerably from those of other observers, and also that the idea of basing a classification of clouds on the differences of origin of the different types is premature, as the agencies which give rise to clouds have not sufficiently been studied. Dr. Hildebrandsson compares Mr. Ley's classification

of clouds with that adopted by the Committee at Upsala.—Ueber Gew dung und labiles Gleichgewicht der Atmosphäre: von Prof. W. von (4 pp.). This paper on the formation of thunderstorms, and on the u equilibrium of the atmosphere, was originally prepared for and sent Chicago Congress, but as it has not yet been published in English, Pr Bezold brings it out in German. He first reminds his readers of the tion Mohn has drawn between heat thundersrtorms and cyclonic thunder The latter are characterised by occurring independently of diurnal period as common by night as by day, in contrast to heat thunderstorms, and more frequent on the coast than inland. A necessary condition for the tion of a thunderstorm is the existence of a strong ascending current a current must carry water up to a level at which it shall be cong hailstones. The very heavy drops of thunder rain can only be expl their being hailstones thawed in their fall. This action also explains which comes on in thunderstorms. All heat thunderstorms are due to equilibrium in the atmosphere, and this is attributable to three separate viz.—1, overheating of the lowest strata; 2, overcooling of the upper agency first pointed out by Prof. W. M. Davis; and 3, retardation change of condition from ice to water. The author points out that agency is very likely to come out at sea, as there the formation of overs air is most easily explained. The paper concludes with an appeal for co observations from ships taken from self-recording aneroids, in order to phenomenon of the sudden increase of pressure in thunderstorms is no at sea as on land.—Eine einfache Formel, die ungefähre Höhe der W dung bei adiabatischen Zuständen zu bestimmen: von R. Hennig (6 pp.).

Rainfall in the East Indian Archipelago 1893. 8vo. 1894. 416 pp.

The number of stations for which the daily rainfall is given is 194, of 104 are in Java and Madoera, and 90 in Sumatra, and the various islands Eastern Archipelago. The station reporting the greatest rainfall in 18 Pelantoengan, Java, 109°59′ E. long. 7°6′ S. lat., the total amount being ins. The greatest monthly fall was 45·05 ins. in February, of which 12·05 ins. fell on the 5th.

Results of Rain, River, and Evaporation Observations made in New Wales during 1893. By H. C. Russell, B.A., C.M.G., Government Astronomer for New South Wales. 8vo. 1894. and 4 plates.

In 1870 there were only 5 stations in the colony reporting rainfall; Russell has an organisation of 1,286 stations. The rainfall for 189 inches, which was very satisfactory. This, with the years 1889, 1890, 1892, makes up a series of years during which the seasons were excep good; indeed, there have been no similar series of equally good years highest floods on the Darling River at Bourke were 34 ft. 8 ins. on Ma and 39 ft. 3½ ins. on July 15th.

Symons's Monthly Meteorological Magazine. January-May 1895. 8vo

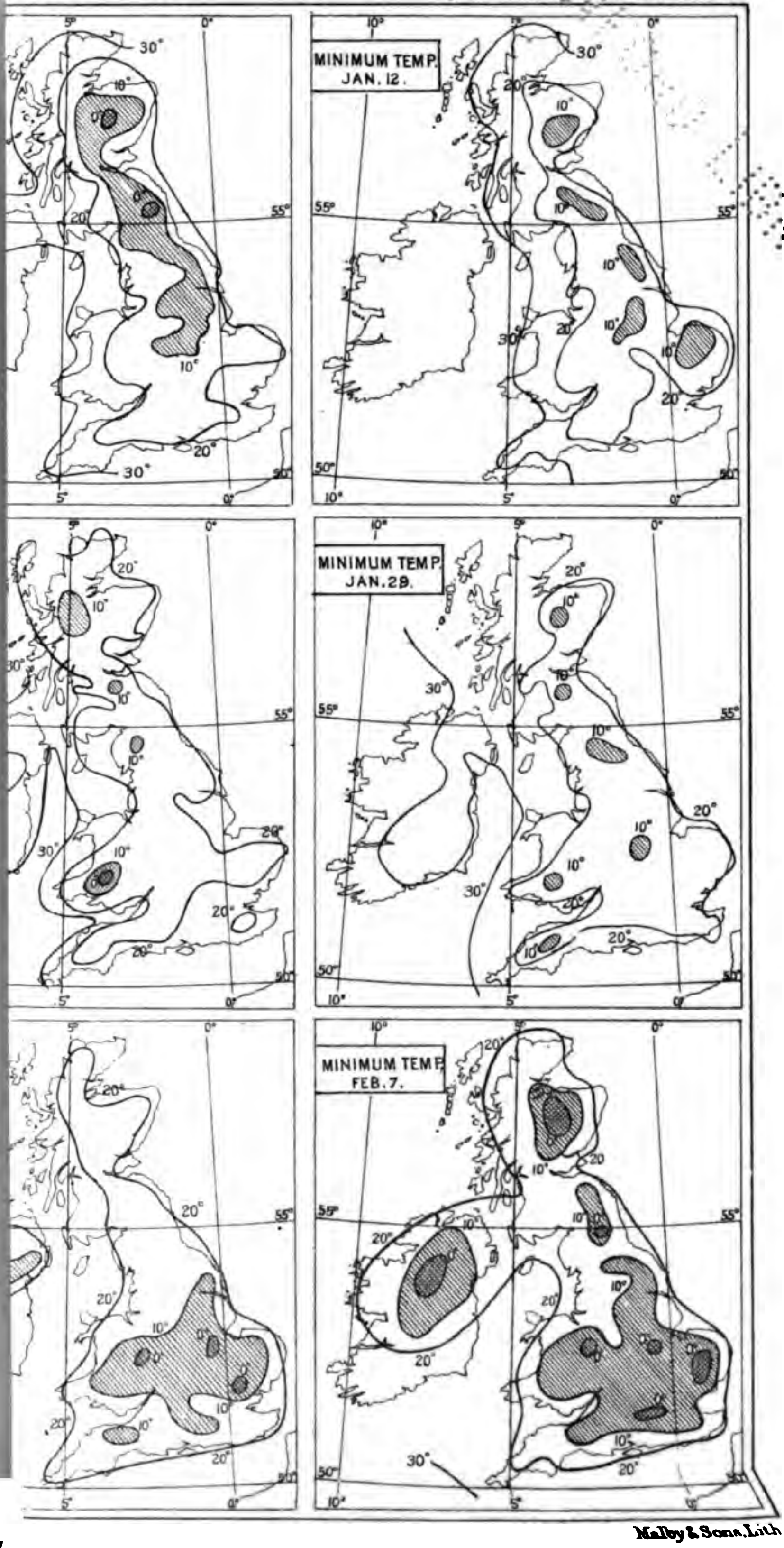
The principal articles are:—The Gale of Saturday, December 22nd (2 pp.).—The Thunderstorm of January 23rd, 1895 (5 pp.).—Classificati Definition of Clouds: by A. L. Rotch (2 pp.).—The Frost of Janua February 1895 (6 pp.).—Earth Temperatures and Water Pipes (11 pp.) Great Gale in the Midlands on March 24th (3 pp.).

The Scientific Roll and Magazine of Systematized Notes. Conduct Alexander Ramsay. 8vo.

The author has started another volume of *The Scientific Roll*, which is to "Climate: Baric Condition." An abstract is given of various boo dealing with the barometer and atmospheric pressure, and also bibliog works on the subject. Parts 1 to 7 have been published.

ITISH ISLES.

Quart. Journ. Roy. Met. Soc. Vol. XXI Pl. 3.



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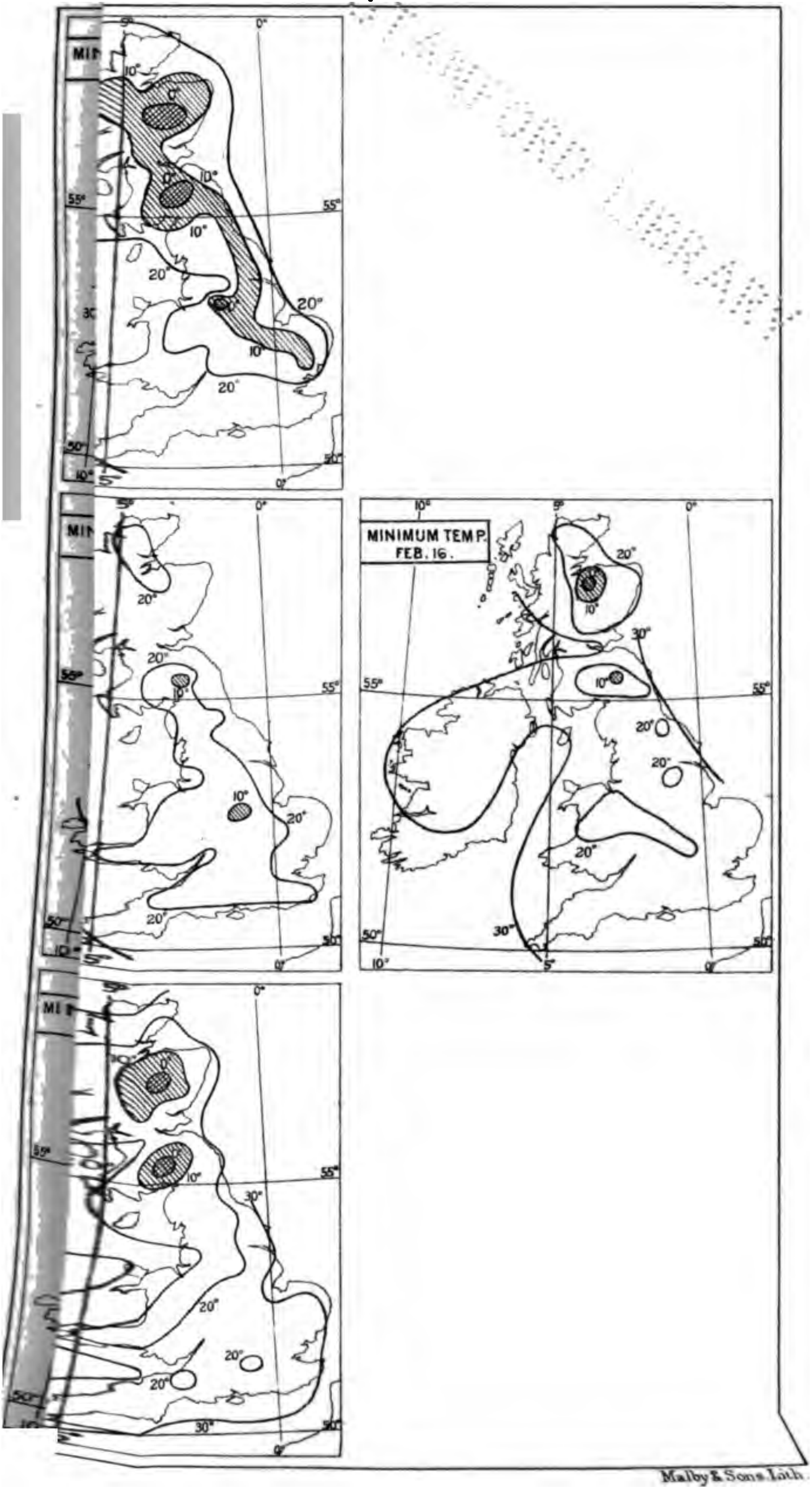

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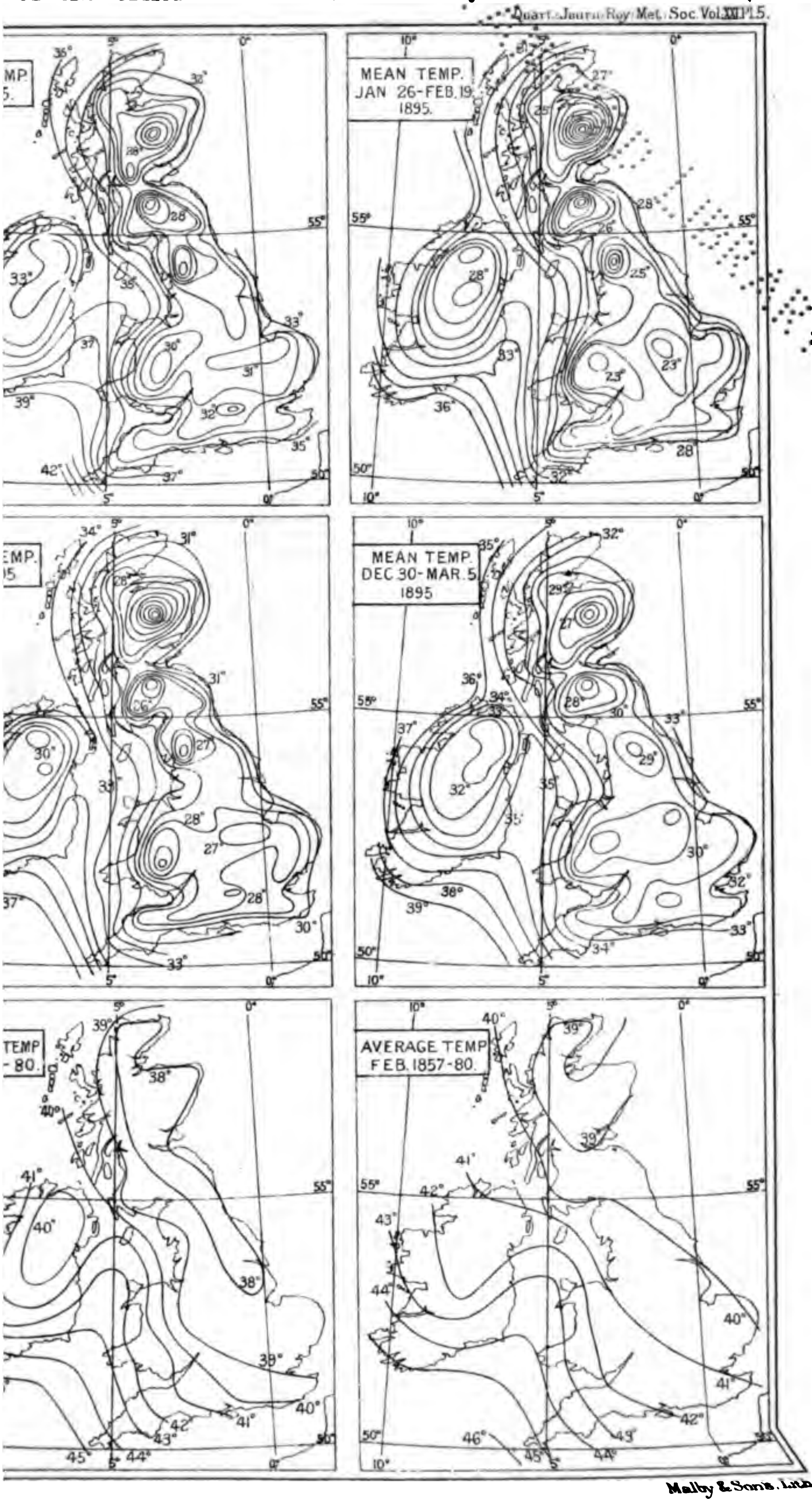
OF JANUARY AND FEBRUARY 1895, OVER THE BRITISH ISLES.

Quart. Journ. Roy. Met. Soc. Vol. XXI Pl. 5.



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THE NOVEMBER FLOODS OF 1894 IN THE THAMES VALLEY.

By G. J. SYMONS, F.R.S., and G. CHATTERTON, M.A., M.Inst.C.E.

(Plate 6.)

[Read May 15th, 1895.]

The mass of data upon this subject is so great, that it is only by classification and by division of labour that it can be brought before the Society in anything even approaching a complete form.

Our paper will therefore be divided into the following sections:—

(1) Notes upon the flood of November 1894, and on previous floods.
(2) Tabular list of the dates of recorded floods.
(3) Chronological list of, and notes upon, Thames floods.
(4) Damage in 1894.
(5) Relative heights of the principal floods since 1750.
(6) The rainfall which produced the flood of 1894.
(7) Rate of progress of flood down the river.
(8) Levels of the flood of 1894, and calculations as to the volume discharged.

There is another preliminary statement which we desire to make, viz. our indebtedness to the Thames Conservancy Board and to its Engineer for unreservedly placing at our disposal the official records. We have purposely thrown the Conservancy Records into tables separate from those containing data otherwise obtained, and it is satisfactory to find that upon points respecting which information is afforded by both sources, the agreement is generally as close as could be expected, when we remember that the Thames, throughout the 150 miles of its course from its source until it reaches Teddington, has not a single automatic recorder of its height.

(1) *Notes upon the Flood of November 1894 and on previous Floods.*

(Contributed by various correspondents, collected from various sources, and arranged approximately from the head of the river downwards to Teddington.)

HUNGERFORD.—The floods here exceeded all previous records; they decreased rapidly on the 15th, and by 10 a.m. on the 16th the streets were nearly clear.

OXFORD, MAGDALEN COLLEGE LABORATORY.—The height of the Cherwell is taken at 10 a.m. daily near Magdalen Bridge, our zero being 178·90 ft. above Ordnance datum. The highest floods since January 1st, 1877, have reached the following altitudes:—

	ft.		ft.
1877, Jan. 5	184·55	1882, Nov. 10	184·15
1880, Feb. 21	184·13	1883, Feb. 12	184·95
,, Oct. 9	184·05	1887, Jan. 21	184·30
1881, Dec. 20	184·04	1894, Nov. 16	184·56
1882, Oct. 26	184·90		

The floods of October 26th, 1882, and of February 12th, 1883, were therefore about 4 inches higher than the recent one, but no other was equal to it. The daily values from October 23rd to November 30th, 1894, were as under:—

	ft.		ft.		ft.
Oct. 23	179·01	Nov. 5	182·05	Nov. 18	183·65
,, 24	179·89	,, 6	181·66	,, 19	183·33
,, 25	179·51	,, 7	181·26	,, 20	182·97
,, 26	179·67	,, 8	181·50	,, 21	182·70
,, 27	180·20	,, 9	181·59	,, 22	182·44
,, 28	180·58	,, 10	181·62	,, 23	182·24
,, 29	180·79	,, 11	181·52	,, 24	181·94
,, 30	180·82	,, 12	181·64	,, 25	181·60
,, 31	181·45	,, 13	182·61	,, 26	181·21
Nov. 1	181·77	,, 14	182·99	,, 27	180·97
,, 2	182·10	,, 15	184·40	,, 28	180·74
,, 3	182·39	,, 16	184·56	,, 29	180·62
,, 4	182·26	,, 17	184·08	,, 30	180·42

J. J. Manby.

OXFORD.—The following are the levels of the floods of 1891 and of 1894, referred to Ordnance datum :—

	1891. ft.	1894. ft.	Excess. ft.
King's Weir, 2¼ miles NW ...	194·85	195·10	·25
Godstow Lock, 1½ miles NW ...	190·78	191·03	·25
Mean of 8 records in the City ...	187·56	188·26	·70
Water Works	183·41	184·80	1·39
New Hinksey	182·52	183·60	1·08
Iffley Road	181·79	183·30	1·51
Iffley Lock	181·85	182·74	·89
Kennington	180·10	181·90	1·80

W. H. White, C.E., City Engineer.

OXFORD.—The flood of 1894 was highest on Friday (16th). Here the 1875 flood was much greater than that of 1852.

ABINGDON.—The rainfall measured at the Sewage Farm at 4 p.m. was:

		ins.	
Nov. 12th	...	1·53	3·65 ins. in three days.
,, 13th	...	·40	
,, 14th	...	1·72	
,, 15th	...	·09	
		3·74	

The level of the water in the Thames, from information supplied by the respective surveyors, was:

Town.	Normal Level. ft.	Flood Level. ft.	Rise. ft.	Date. Nov.
Oxford	179·60	183·30	3·70	16th
Abingdon[1]	162·00	168·96	6·96	16th
Reading	120·50	127·32	6·82	
Henley	...	...	6·25	16th
Maidenhead	73·62	81·56	7·94	17th
Windsor	58·86	67·73	8·87	

The level of the Ock river, in Ock Street, on November 16th was 172·22 ft. above Ordnance datum, and that of the Stert stream, near the Railway Station, on the 14th was 176·37, and the flooding at Abingdon was due rather to the volume of water brought down by these streams than to that brought down by the Thames.

At Abingdon Lock the 1894 flood was 4 ins. above that of 1875.

At Clifton Bridge the 1894 flood was 6 ins. above that of 1875.

G. Winship, C.E., Boro' Surveyor.

LONG WITTENHAM.—The following have been the principal floods for nearly 200 years. The heights are the heights above high water mark :—

1764, Jan. 14 —The greatest for 30 years.

1768, Dec. 3, 7 ft. 7½ ins.—Rapid thaw after snow; greatest for 30 years.

[1] Opposite St. Helen's Church.

1774, Mar. 10,	8 ft. 1 in.	—Greatest for a century; carried away Henley Bridge.
1809, Jan. 27,	9 ft. 1 in.	—Greatest on record, 5 ins. above 1894.
1821, Dec. 26?	8 ft. 10 ins.	
1852,	7 ft. 10 ins.	
1875, Nov. 15,	8 ft. 1 in.	
1894, Nov. 16,	8 ft. 8 ins.	

In 1894 the level was nearly uniform from 10 a.m. to 4 p.m. on 16th, but the absolute maximum was at 4 p.m. In 1875 the flood was also highest at 4 p.m., but on the 15th, not on the 16th. *F. C. Clutterbuck.*

LITTLE WITTENHAM.—Here the 1894 flood exceeded that of 1821 by 4½ ins., but it was 7½ ins. below that of 1809. *F. C. Clutterbuck.*

DORCHESTER.—1894 flood not so high as 1809, but 5 ins. above 1821.

SHILLINGFORD.—In the malthouse wall by the riverside are two stones—one records the level of the flood of December 3rd, 1768, and the other (1 ft. 6½ ins. higher) that of January 27th, 1809. The flood of 1894 was 7 ins. above that of 1768, and 11½ ins. below 1809; it exceeded that of 1852 by 1 ft. 5 ins., and that of 1875 by 2 ft. 4 ins.

PRESTON CROWMARSH.—The 1809 mark at "The Swan" was not reached by 1 ft. 9 ins.

WALLINGFORD.—The highest point in 1894 was 151·40 ft. above Ordnance datum, or 10 ft. 6 ins. above summer level. At Rush Court the 1894 flood was 12 ins. below that of January 27th, 1809, and 14 ins. above that of 1875. Below Wallingford Bridge the excess above 1875 was greater, being 17½ ins.

GORING.—The flood in 1894 was highest on the night of the 15th, and until 2 a.m. on the 16th; it was about 11 ft. above ordinary level.

WHITCHURCH.—The following notes are in the Register of this Parish:—

1765, November. A greater flood than ever known.

1770, February. Another flood, but 4 ins. lower.

1774, February (? March). A flood 14 ins. higher than either of the above.

1809, January. A very high flood.

By the description of the local marks which the flood of 1809 attained, it may be judged that 1894 was the exact counterpart. The contributing cause of the late flood was—that all the local small streams were greatly overcharged by the first fall on November 12th of 1·56 in., before they had discharged came the second fall of 1·60 in. with a repetition by the brooks just as the head waters of the Thames delivered the accumulation from above. On Thursday, 16th, at 4 p.m., I had seen my neighbour's horses put up in my stables without reason for fear, and at 9 p.m. the horses were standing a foot deep in water. This height continued till Saturday, 17th, when a marked decline was visible, which rapidly increased. *J. Slatter.*

MAPLEDURHAM.—On the 15th, at noon, the water in the Parish Church was several inches above the mark of the 1764 flood.

READING.—In the register of St. Mary's Parish, it is stated that on Jan-

uary 18-19, 1673, there was a greater flood than could be remembered by any person then living. The ordinary level of the Kennet above the weir at the pumping station is 116·25 ft. above Ordnance datum; in 1891 it rose to 122·08 ft., and in 1894 to 122·78 ft., or an excess of 9 ins. above 1891. The flood of November 17th, 1852, was 2 ins. higher than that of November 16th, 1875. At Caversham Bridge the ordinary summer level is 120·50 ft. above Ordnance datum, in October 1891 it rose to 124·82 ft., and on November 16th, 1894, to 126·05 ft.

SONNING.—The great floods of this century have been—

1809				
1821				
1852	Nov. 17	...	3 ft. 3 ins.	above high water mark
1875	Nov. 16	...	3 ft. 5 ins.	
1882	Oct. 28	...	3 ft. 3½ ins.	
1891	Oct. 24	...	3 ft. 2 ins.	
1894	Nov. 16	...	4 ft. 2 ins.	

I have not the precise figures for the early years, and owing to changes in the river they would not be strictly comparable. *J. Witherington.*

HENLEY.—The flood in 1894 rose 1 foot during the night of November 17th, and began to fall on the 18th. It was 12½ inches less than that of 1809, but 14 inches greater than that of 1852. *R. Pratt*, Boro' Surveyor.

MARLOW.—The flood was highest on the 17th, and fell on the 18th. It was well above those of 1852 and 1875.

BOURNE END.—The 1894 flood was 6 or 8 inches higher than that of 1852, and higher than known by any person now living. *E. Townsend.*

COOKHAM.—The flood at 4 a.m. on 18th (? 17th) was 9 inches above any existing record.

BOULTER'S LOCK.—The flood was highest at 2.15 a.m on 17th; it was 5 ft. 3 ins. above high water level, and 1 foot higher than previously recorded.

TAPLOW.—The 1894 flood was from 5 to 12 inches above that of 1852.

MAIDENHEAD.—The following levels were taken as under:—

Oct. 2,	level of river	70·62 ft.	above Ordnance datum.	
Nov. 1	,, ,,	75·42 ,,	,,	
,, 15	,, ,,	80·00 ,,	,,	
,, 16	,, ,,	81·00 ,,	,,	
,, 17	,, ,,	81·56 ,,	,,	

The flood was from 6 to 8 inches above that of 1852.

W. Fletcher Robinson, C.E.

SLOUGH.—At the Waterworks the river rose 22 inches between the night of the 17th and 6 a.m. on the 18th.

An engineer reports that the 1894 flood was 4 inches above that of 1852, and 18 inches above that of 1877. *G. Bentley.*

WINDSOR,—Higher than any previous record, the nearest being in 1742, which was a few inches less.

ETON.—In the College buttery is marked the level of the flood of March 10-11, 1774; the flood of 1894 did not reach it by 4½ inches.

R. F. Grantham, C.E.

STAINES.—The 1894 flood here was 10 inches below that of 1821. The following are the flood levels at Staines (of 51 ft. and upwards) as given in the Appendix to the *Report of the Select Committee on Thames Floods Prevention* (1877), but referred to Ordnance datum;—

	ft.	in.		ft.	in.
1821—	52	6	1841,	51	1
1823—	52	3	1852, Nov. 18—	51	8
1824—	51	3	1875, ,, 17—	51	6
1828—	51	2	1877, Jan. 11—	51	5
			1894, Nov. —	51	8¼[1]

R. F. Grantham, C.E.

CHERTSEY.—Flood just equal to that of 1852.

SHEPPERTON.—The 1894 flood was five inches above that of 1821.

SUNBURY.—The 1894 flood is said to have been the highest since 1742, 4 inches above that of 1821, and 8 inches above that of 1852.

E. MOLESEY.—The flood in the Mole was highest on November 14th, that in the Thames on the 18th. This flood was several inches higher than that in 1877. *M. C. Jenkyns.*

E. MOLESEY.—The flood was highest from 9 a.m. to noon on the 18th; it was 14 inches above that of 1877, but 8½ below that of 1821.

HAMPTON.—There is a tablet at the base of Mr. T. Green's house (Old Ferry House) which records the level of the flood of March 1774, but this was not reached by about a foot.

At Spring Grove Wall the record of the 1852 flood was submerged 9 ins.

KINGSTON.—The flood was 11 ft. 6 ins. above summer level, and 7 inches higher than that of 1877.

TEDDINGTON.—The flood was above all recent ones, but 10 inches below that of 1821.

Below Teddington, therefore tidal.

TWICKENHAM.—A greater flood than that of 1875; it was highest at the top of the evening tide on November 18th. There is a mark here of the flood of March 1774; that mark is 21 ft. 9½ ins. above Ordnance datum, the recent flood did not reach it by 2 ft. 9½ ins. *G. B Laffan, C.E.*

(2) *Tabular List of the Dates of recorded Floods.*

Note.—As far as possible these dates are those of land floods. In London damage has frequently resulted from high tides. The present paper deals with land floods above Teddington, and therefore above the reach of the tides; some of the very early entries may refer to tidal injury, but all known cases have been excluded.

[1] This last was taken by myself at the railway bridge over the river.

Year.	Date.	Year.	Date.	Year.	Date.
9	—	1765	Nov.	1866	Jan. 18
48	—	1768	Dec. 3	1867	Mar. 27
479	—	1770	Feb.	1869	Jan. 9
973	—	1774	Mar. 10-11	,,	Dec. 20
1099	—	1795	Feb. 12	1872	Jan. 26
1240	—	1809	Jan. 27	,,	Dec. 17
1555	Sep. 21	1821	Dec. 26	1875	Nov. 15-18
1564	Sep. 20	1823	—	1876	Dec. 9
1660	Nov. 11	1824	—	1877	Jan. 11
1678	Jan. 18-19	1828	—	1882	Oct. 28
1680	June	1836	—	1883	Feb.
1742	—	1841	Jan. 16	1891	Oct. 24-25
1763	—	1852	Nov. 17-18	1894	Nov. 16
1764	Jan. 14	1853	July 18		

(3) *Chronological List of, and Notes upon, Thames Floods.*

A.D. **9.**—The earliest recorded Thames flood. It is said to have overflowed the banks, and destroyed many inhabitants.

48.—The Thames overflowed, the waters extended through four counties, 10,000 persons were drowned, and much property was destroyed.

479.—The Thames much flooded, both above and below London; great damage.

973.—Thames greatly overflowed, many persons drowned.

1099.—Thames greatly flooded on festival of St. Martin.

1240.—Thames greatly flooded from rains. Extended above 6 miles at Lambeth.

1555.—Sept. 21st, great flood in the Thames owing to excessive rains. It overflowed its banks, and Westminster Hall was flooded.

1564.—Sept. 20th, Thames greatly overflowed.

1660.—Nov. 11th, great floods in the Thames valley.

1680.—June, great floods at Oxford.

1762.—Great flood in the Thames valley.

1763.—The vast extent of meadow from the source of the Thames to the river's mouth was almost covered with water.

1764.—In the Register book of Bicester is a note that "It began raining June 19th, 1763, and continued mostly wet weather till the beginning of February 1764; and [there] was a perpetual flood for the most part of November, December, and January, 15 weeks." A report from Abingdon dated February 11th, 1764, states that great distress prevailed among the bargemen, as they had not been able to work for two months, by reason of the floods, and one from Oxford ten days later (February 21st) says that the first barges started that day as the floods have so much abated.

1768.—Heavy rains at the end of November. On December 1st the Thames at Reading rose 2 ft. 6 ins. in less than half an hour, to a point

higher than had been observed for 80 years. The Kennet and Loddon overflowed their banks. Burfield Bridge and part of Twyford Bridge were washed away. The Isis at Oxford rose 1 ft. 6 in. above any existing high water mark. The Exeter coach with six passengers and four horses was carried away by the flood near Staines, and all were drowned. The flood there was so excessive that 1,000 men were engaged in making drains to carry it off.

1774.—March 12th, great flood in the Thames, partly tidal but chiefly due to excessive rain. At Chesham and at Amersham (both in Buckinghamshire) a boat could be rowed through the town and the water rose 1 ft. above any previous flood. One farmer lost over 400 sheep. At Sandford, 3 miles from Oxford, and at Shillingford the brook was so swollen that a horse could swim over the high road. The West Country coaches were stopped at Slough and Staines. A chaise and pair of horses were washed away from Windsor. At Kingston the water reached the Town Hall, and it undermined the church, doing damage to the extent of £300, and it also tore open some graves. At Teddington the water reached the church, and rose in it to a considerable height. It did not actually flood Westminster Hall, but was within a few feet of it; nearer in fact than for forty previous years.

1795.—Heavy flood in the middle of February. At High Wycombe inhabitants had to take to upper rooms. At Maidenhead carriages could pass through the flood only by opening the doors and letting the water flow through. At Staines the Thames on the 12th was 9 ins. higher than on the 11th, and it was so high that the Southampton coach was upset. At Colnbrook, owing to the road being covered, four vehicles were upset, viz. the Gloucester and the Windsor coaches, a chaise and a waggon. At Hampton and Sunbury much land was under water, and boats were used in the streets of Kingston.

1809.—Flood at the end of January, due to rain melting deep snow. At Stony Stratford, on the 29th, a waggon and team were overturned by the flood and the driver and nine horses were drowned. So deep was the "brook" that not a vestige of the waggon could be seen, and it was six hours before the accident was discovered. A farmer going from Windsor to Stoke was washed into a field with his cart and horse. He was rescued by a boat. H.M. George III. had to remain at Windsor, as the ford at Datchet was impassable, and Eton Bridge had been carried away.

There was a flood four days previously (January 25th) which carried away bridges at Deptford and Lewisham, but it may have been tidal.

1809.—Another flood occurred at the end of April. On the 26th the Windsor coach was overturned into the water on the Eton College playing fields. Boats were used in the streets, and the King had to go to London by Egham and Staines, as the road through Slough was flooded.

1821-2.—Flood in the last days of December 1821. The Kennet and the Thames overflowed to a greater extent than for 15 [? 12] years. The road from Reading to Caversham was impassable, one bridge being carried away, and all communication with Oxford was stopped. At Pangbourne some houses had several feet of water in their ground-floor rooms. The

flood at Maidenhead was about the same as in 1795, but not so high as about 86 years ago [? 1774]. At Henley it was said to be the highest since 1809. There was no communication between Egham and Staines except by boat. On December 29th the water reached half way up the market place at Kingston.

1823.—A sudden flood at the beginning of November. Seventy sheep were drowned near Aylesbury. The flood at Oxford was reported to be on November 1st higher than remembered, at Windsor also it was said to be the greatest for many years, Eton was surrounded and no one could traverse the streets except in a cart or boat, Windsor Little Park was flooded and no carriages could reach Windsor from Datchet.

1841.—January 16th. Heavy snow was lying over much of the Thames valley, but there seems to have been, besides a thaw, some exceptional rain or bursting of a bank near Cranbourne (2 miles south of Windsor), for in the course of half an hour after 9 p.m. so much water poured into Windsor that many of the streets were 4 ft. deep. At the Adelaide Hotel in Sheet Street, in less than 10 minutes from the first indication of a flood the cellars were completely filled. The flood continued to rise gently till about 1 a.m., and then subsided. A policeman hearing dogs crying called up the owner, who found his stable with 4 ft. of water in it, the horse in great distress, and the two dogs nearly exhausted with swimming and barking. The flood covered the Eton playing fields about 3 ft., and there were also considerable floods near West Drayton.

1852.—The Duke of Wellington's flood, which was general over the country, was one of the great ones in the Thames. A correspondent at Charlbury, Oxon., said (referring probably to November 12th to 19th). "The Evenlode Valley has for more than a week been like an immense lake." Of Oxford on November 15th it was said, "This city stands literally in a sea of water, the whole of the surrounding country being flooded." The report from Reading (18th ?) says, "No parallel flood has occurred since 1841, and none exceeding it except that in 1809, which was produced by the sudden melting of deep snow. The Thames was highest on November 17th, but the Kennett was higher on November 28th. Caversham lock was much damaged." At Windsor (on 15th ?) part of the Home Park was 4 ft. under water, but even that was exceeded 12 years ago (*i.e.* in 1841). After about the 19th the flood decreased until the 23rd, but then it turned to rise, and on the 25th was as high as ever. At Putney the towing path was 6 ft. under water. Four miles of the Great Western line was flooded between Hanwell and Paddington.

1853.—Excessive rain on July 13th and 14th, producing floods and washing away much hay. For miles on the eastern side of Banbury little but water could be seen, the Cherwell soon overflowed, and one of the mills was more deeply flooded than it had been for 50 years. In passing Reading it flooded much of the town, and at Swallowfield the meadows were under 8 ft. of water. This flood appears to have been even more disastrous on the Ouse, north-east of the Thames basin.

1866.—Slight floods at Oxford and in the Thames between January 16th and February 10th.

1867.—Thames over its banks at Windsor on March 27th.

1868.—On December 29th, Christ Church Meadow, Oxford, was under water, and so was most of the low-lying land near the river.

1869.—Heavy rains in the first week of January produced considerable floods. Much land flooded near Reading. A horse and cart were washed away near Caversham, and at Sonning and Twyford the floods were reported as higher than for many years. The highest point at Maidenhead seems to have been on January 9th.

1869.—Slight floods were produced about December 20th by rain during the previous week.

1872.—A considerable flood in Christmas week. Oxford was surrounded by water, punts had to be used in some of the streets of Windsor and Eton, but the flood there was reported as 2 ft. below that of 1852. At Maidenhead it was reported as higher than any since 1852.

1875.—July 15th-23rd. This was the period of the great Monmouthshire floods, and the Thames basin, though not suffering with equal severity, had a very heavy rainfall. Houses flooded in many districts, and railway traffic interrupted.

1875.—November 10th-17th. A very heavy flood due to continuous rains, producing, along the lower parts of the river, higher floods than had been reported since 1852.

1877.—January 11th. A high flood which had been accumulating from about Christmas reached its maximum on this day, and very nearly equalled the flood of 1852. There was the usual discomfort and injury in the upper part of the river, and as it synchronised with a very high tide, there was great destruction in Southwark and all low-lying places along the river.

1882.—October 24th. Heavy rains in the middle of October, resulting in considerable floods and consequent destruction of property.

1891.—October 25th. An extremely wet month, floods rose steadily and at Oxford were highest on 25th.

(4) *Damage in 1894.*

With reference to the damage done by the 1894 flood, it is impossible to enter into details. It would be an endless repetition of the story of flooded homes, spoiled furniture and provisions, of food, coals and letters conveyed by boats, and delivered into upper windows. We ourselves visited many of the houses which had had from 2 to 4 ft. of water in the sitting rooms. We heard of one where the billiard room was filled almost up to the ceiling. And these were not isolated cases, but streets, and roads, and crescents, we might almost say towns, have been built upon land which the slightest inquiry would have shown was far below the flood level of 1821, and therefore unfit for human habitations of the usual kind. One of the sad and yet ludicrous features of a visit to the flooded districts was to see, rising through

TABLE I.—Excess or Defect (in feet and inches) of previous Flood Heights above that of 1894, from various sources.

Station.	1764.	1765.	1768.	1770.	1774.	1809.	1821.	1823.	1824.	1828.	1841.	1852.	1875.	1877.	1882.	1891.
Magdalen Bridge, Oxford ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	— ·10½
Long Wittenham	..	..	—1·0½	..	— ·7	+ ·5	+·2	..	..	..	..	— ·10	— ·7	..	..	..
Clifton Bridge	..	..	..	..	..	..	..	..	..	..	..	..	— ·6	..	..	..
Little Wittenham	..	..	..	..	..	+ ·7½	—·4½	..	..	..	..	..	..	..	..	..
Dorchester	..	..	..	..	..	+	—·5	..	..	..	..	..	..	..	..	..
Shillingford	..	..	— ·7	..	..	+ ·11½	..	..	..	..	..	—1·5	—2·4	..	..	..
Rush Court	..	..	..	..	..	+1·0	..	..	..	..	..	..	—1·2	..	..	..
Preston Crowmarsh	..	..	..	..	..	+1·9	..	..	..	..	..	..	..	..	..	..
Below Wallingford Bridge ..	..	..	..	..	..	..	..	..	..	..	..	..	—1·5½	..	..	..
Whitchurch	..	(—2·2)	..	(—2·6)	(—1·0)	·0	..	..	..	..	..	..	..	..	..	..
Mapledurham	(—·6)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Caversham Bridge	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	—1·3
Sonning	..	..	..	..	..	..	..	..	..	..	..	— ·11	— ·9	—1·0½	—·10½	—1·0
Henley-on-Thames	..	..	..	..	..	+1·0½	..	..	..	..	..	—1·2	..	..	..	..
Bourne End	..	..	..	..	..	..	..	..	..	..	..	— ·7	..	..	..	..
Taplow	..	..	..	..	..	..	..	..	..	..	..	— ·8½	..	..	..	..
Maidenhead	..	..	..	..	..	..	..	..	..	..	..	— ·7	..	..	..	..
Slough	..	..	..	..	..	..	..	..	..	..	..	— ·4	..	—1·1	..	..
Windsor	..	..	..	..	..	..	..	..	..	..	..	—1·2	—1·4	—1·3	..	..
Datchet	..	..	..	..	..	..	..	..	..	..	..	—1·0	..	..	..	..
Eton	..	..	..	..	+ ·4½	..	..	..	..	..	..	..	..	..	..	..
Staines	..	..	..	..	..	..	+·9½	+·6½	—·5½	—·6½	—·7½	— ·0½	— ·2½	— ·3½	..	..
Chertsey	..	..	..	..	..	..	..	..	..	..	..	·0	..	..	..	..
Shepperton	..	..	..	..	..	..	—·5	..	..	..	..	..	..	..	..	..
"	..	..	..	..	..	..	—·8	..	..	..	..	..	..	..	..	..
Sunbury	..	..	..	..	..	..	—·4	..	..	..	..	— ·3	..	..	..	..
Molesey	..	..	..	..	..	..	+·6	..	..	..	..	..	..	..	..	..
"	..	..	..	..	..	..	+·8½	..	..	..	..	..	..	—1·2	..	..
Hampton	..	..	..	..	+1·0	..	..	..	..	..	..	— ·9	..	..	..	..
Kingston	..	..	..	..	..	..	..	..	..	..	..	..	..	— ·7	..	..
Teddington	..	..	..	..	..	..	+·10	..	..	..	..	..	— ·7	..	..	..
Twickenham	..	..	..	..	+2·9½	..	..	..	..	..	..	..	..	..	..	..

Therefore the 1894 flood was equalled or exceeded only in 1774, 1809, 1821 and 1823.

the water in dozens of localities, posts bearing large posters announcing "Eligible building land to let." Doubtless by this time some energetic speculator is busy erecting thereon a "rheumatic trap" on what now looks beautiful in its mantle of green and of flowers, and he is tolerably sure to find some young couple to take possession of it and find too late that beauty is not everything. That the local authorities ought to pass such plans and to undertake to sewer such roads we deny; but they have done so, and untold misery is the result.

(5) *Relative height of the principal Floods since 1750.*

Our next tables are adapted for reference rather than for reading aloud. They both have one object, that of showing the relation of the height of the 1894 flood to that of previous floods, and they differ only in this, that one is compiled from a variety of sources, and attempts to go back more than 180 years; the other is compiled entirely from data supplied by the Thames Conservancy, and deals almost exclusively with the floods of the last 20 years. Roughly the result is to show (as might have been expected) that each flood has, so to speak, an individual character; some are very high in one part of the river, others in another. For instance, the 1894 flood seems to have been lower than that of 1821 near Oxford, Staines, and Teddington, but higher at Long Wittenham and near Shepperton. Again, the 1774 flood was unimportant in the Upper Thames, but it carried away Henley Bridge, and in the vicinity of Teddington was far above 1894 or any other on record.

Taking, however, a general view of all the facts, we think that it is certain that the 1894 flood was the greatest for 70 years.

(6) *On the Rainfall which produced the Flood of 1894.*

The heavy rain at the end of October did not do much mischief, and it had nearly all passed Teddington before the second heavy rain came, but that found the soil thoroughly saturated, and therefore produced that "water running off water" which is well known as a great factor in producing floods, and the recent disasters are but one more illustration of the inevitable resultant mischief.

The Tables give the following information :—

Table II. The relation of the total of September, of October, and of November to the mean at 10 stations, over the whole area—September was 17 °/$_o$ below ; October 25 °/$_o$ above ; November 60 °/$_o$ in excess.

Table III. The fall each day from October 23rd to November 18th at 50 stations (p. 202).

Table IV. The mean of the 25 western, of the 25 eastern, and of all the returns for each day.

(7) *Rate of Progress of Flood down the River.*

We expressed at the beginning of this paper our regret at the absence o automatic records of the flood levels, and this absence renders it impossible

'ABLE II.—Relation of the Rainfall of September, October, and November 1894, to the Average 1880-89.

Station.	September.		October.		November.		October and November.	
	Total.	Difference from Average.	Total.	Difference from Average.	Total.	Difference from Average.	Total.	Difference from Average.
	in.	in.	in.	in.	in.	in.	in.	in.
[arlborough, Mildenhall ..	2·40	— ·25	3·30	+ ·07	6·48	+3·08	9·78	+3·15
echlade	2·24	— ·19	4·41	+1·68	4·73	+1·65	9·14	+3·33
'ewbury, Welford Park ..	3·12	+ ·48	4·04	+ ·82	6·29	+2·91	10·33	+3·73
anbury, Bloxham	2·35	— ·33	3·54	+ ·51	3·66	+ ·66	7·20	+1·17
xford, Mag. Coll. Laboratory	1·80	— ·63	3·26	+ ·48	4·76	+2·13	8·02	+2·61
lton, Ashdell	2·71	— ·48	5·07	+1·48	6·04	+2·08	11·11	+3·56
'inslow, Addington Manor ..	1·77	— ·90	3·07	— ·02	4·36	+1·43	7·43	+1·41
lough, Upton	1·96	— ·51	3·76	+ ·89	3·16	+ ·55	6·92	+1·44
'unstable, Kensworth ..	2·28	— ·52	3·49	+ ·05	5·75	+2·94	9·24	+2·99
'orking, Abinger Hall ..	2·10	—1·05	5·50	+1·74	5·01	+1·31	10·51	+3·05
Means	2·27	— ·44	3·94	+ ·77	5·02	+1·87	8·97	+2·64

o state the rate at which the flood passed down the river. By this of ›ourse we do not mean the flow of the water itself, but the sequence in time ıt which the highest point occurred lower and lower down the river. And it nust be remembered that we are not considering the rate of progress of a nass of water, suddenly released at the end of a single channel, but of the ›assage of a flood along the Thames, complicated by the inflow at many points ›f affluents, some of them nearly as important as the main river. The note 'rom East Molesey, that the Mole was highest *four days* before the Thames, llustrates the difficulty (without a proper organisation) of computing and ›redicting the time and height of coming floods, but the problem has been ›olved for the Rhone, for the Seine, for the Loire, and for many rivers in

TABLE IV.—Average Rain over the Thames Watershed above Teddington, October 23rd to November 18th, 1894.

Date.	Twenty-five Westerly Stations.	Twenty-five Easterly Stations.	Fifty Stations, Daily fall.	Date.	Twenty-five Westerly Stations.	Twenty-five Easterly Stations.	Fifty Stations, Daily fall.	Date.	Twenty-five Westerly Stations.	Twenty-five Easterly Stations.	Fifty Stations, Daily fall.
	in.	in.	in.		in.	in.	in.		in.	in.	in.
October 23	·15	·09	·12	November 2	·11	·05	·08	November 12	1·25	·99	1·12
24	·61	·71	·66	3	·12	·20	·16	13	·84	·38	·61
25	·07	·04	·06	4	·01	·01	·01	14	·93	1·12	1·02
26	·65	·46	·55	5	·05	·06	·05	15	·04	·10	·07
27	·16	·20	·18	6	·01	·01	·01	16	·02	·07	·04
28	·44	·49	·46	7	·59	·55	·57	17	·01	·02	·02
29	·15	·13	·14	8	·07	·02	·05	18	..	..	..
30	1·05	1·09	1·07	9	·11	·12	·11				
31	·06	·05	·06	10	·12	·15	·14				
November 1	·25	·13	·19	11	·43	·50	·47	Total ..	8·30	7·74	8·02

TABLE III.—Rainfall which produced the Flood on the Thames in November 1894.

Date.	Ashley Rectory [Tetbury.]	Cheltenham, Southam Villa.	Cirencester, Further Barton.	Broad Hinton.	New Swindon.	Fairford, Kempsford.	Fairford, Hatherop Rectory.	Bourton-on-the-Water.	Moreton-in-Marsh, Longborough.	Great Barrington.	Lechlade.	Marlborough, Mildenhall.	Lamborne.	Banbury, Sibford Ferris.	Hungerford, Kintbury.	Newbury, Welford Park.	Abingdon Union.	Oxford, Mag. Coll. Laboratory.	Steeple Aston.	Grimsbury [Banbury].	Garsington.	Little Wittenham.	Yattendon Court.	Basingstoke, Sherborne St. John.	Alton, Ashdell.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
October 23	·20	·26	·18	·25	·16	·15	..	·34	·18	·16	·06	·06	·14	·14	·20	·17	·09	·26	·10	·11	..	..	·08	·14	·34
24	·94	·40	·73	·45	·36	·95	·70	·50	·49	·60	·87	·60	·54	·41	·51	·48	·59	·60	·36	·32	·79	·81	·49	·87	·77
25	·12	·10	·03	·04	·05	·10	·02	·08	·08	·05	·03	·08	·03	·06	·06	·13	·03	·01	·03	·05	·14	·12	..	·01	·35
26	1·20	·49	1·12	·98	·78	·68	·93	·85	·67	1·08	·80	·45	·45	·59	·42	·36	·28	·35	·85	·90	·28	·27	..	·73	·81
27	·33	·28	·23	·14	·24	·23	·10	·19	·25	·12	·22	·12	·12	·18	·09	·13	·06	·06	·09	·10	·03	..	·15	·34	·21
28	·53	·30	·61	·54	·52	·34	·40	·60	·35	·41	·31	·36	·46	·29	·50	·44	·36	·27	·31	·26	·50	·41	·48	·52	·80
29	·19	·16	·22	·19	·36	·13	·11	·03	·10	·15	·09	·08	·18	·04	·13	·14	·08	·08	·05	·05	·30	·35	·12	·13	·33
30	1·22	·75	1·50	1·04	1·28	1·41	1·43	·88	·78	·96	1·48	·94	1·25	·56	·98	1·20	1·32	1·01	·76	·43	·78	1·28	1·23	·84	·93
31	·08	·07	·10	·08	·07	·04	·05	·08	·11	·08	·03	·10	·08	·06	·11	·08	·01	..	·07	·05	..	·02	·08	·09	·09
November 1	·45	·36	·41	·28	·21	·18	·23	·36	·31	·25	·16	·51	·47	·29	·21	·18	·19	·18	·20	·19	·14	·08	·12	·21	·21
2	·04	·01	·05	·18	·15	·20	·15	·06	..	·12	·27	·13	·14	·06	·14	·25	·13	·13	·12	·03	..	·07	·09	·09	·06
3	·10	·02	·06	·12	·03	·13	·23	·15	·05	·26	·03	..	·02	·16	·16	·13	·01	..	..	..	..	·24	·41	·45	·20
4	·01	..	·02	·02	..	..	·01	·01	..	..	..	..	·03	..	·01	·03	..	...	..	..	·12	..	..	..	·04
5	·01	·01	·01	·04	·02	·05	·04	·02	..	·02	·05	·11	·12	·01	·17	·08	..	·06	..	..	..	..	·12	·04	·08
6	..	..	..	..	·01	·04	..	..	·03	·01	..	..	..	·01	·01	..	..	..	..	..	..	..	..	·01	·10
7	·57	·49	·68	·57	·38	·40	·39	·62	·55	·45	·39	·65	·69	·56	·88	·78	·78	·98	·45	·45	·74	·54	·54	·73	·50
8	·17	·18	·20	·16	·16	·07	·11	·13	..	·10	·02	..	·14	·01	·09	·10	..	·05	·02	..	..	..	·02	..	·14
9	·10	·03	·24	·11	·06	·11	·20	·06	·16	·08	·15	·24	·07	·05	·11	·11	·12	·04	·08	·07	..	..	·14	·17	·14
10	·20	·18	·10	·15	·16	·11	·05	·23	·14	·13	·10	·09	·07	·12	·14	·09	·05	·06	·07	·08	·11	·10	·13	·20	·27
11	·45	·17	·37	·80	·62	·36	·32	·28	·16	·28	·30	·54	·73	·22	·56	·56	·46	·57	·26	·25	·83	..	·46	·52	·78
12	1·23	·92	1·13	1·71	1·55	1·16	1·15	1·06	1·30	1·11	1·30	1·85	1·47	1·24	1·34	1·66	1·35	1·00	1·19	1·05	·79	1·12	1·25	1·05	·97
13	·95	·93	1·17	·80	·91	·60	1·04	1·38	1·03	1·00	·66	·51	·89	·75	·77	·74	·58	·79	·91	·68	1·17	·88	·62	·48	·80
14	·60	·41	·58	·98	·93	1·02	·52	·44	·58	·78	1·10	1·49	1·40	·54	1·61	1·34	1·19	·73	·63	·40	·63	1·42	1·35	1·27	1·27
15	·06	·05	·01	·01	..	·01	..	·02	·02	..	..	·03	·01	..	·04	·03	·01	·02	·01	..	..	·27	·04	·14	·12
16	..	·02	·01	·03	·02	·01	..	..	·02	..	..	·04	·05	·01	·04	·02	·01	..	·01	..	..	·04	·03	·04	·04

TABLE III.—RAINFALL WHICH PRODUCED THE FLOOD ON THE THAMES IN NOVEMBER 1894—*Continued.*

Date.	Strathfield Turgiss.	Reading, Portland Place.	Henley-on-Thames, Northfield House.	Watlington, Pyrton Manor.	Winslow, Addington Manor.	Wendover, Halton Gardens.	Maidenhead, Hedsor.	Wokingham, Binfield Park.	Sandhurst Lodge.	Greatham, King's Holt.	Farnham, Great Down, Seale.	Chertsey, Ottershaw.	Slough, Upton Hall.	Amersham, The Plantation.	Great Berkhampstead, Rosebank.*	Kensworth [Dunstable].	Cranleigh Common.	Abinger Hall.	Ashtead, D'Abernon Chase.	Kew Observatory.	Pinner Hill.	Watford, Frogmore.	St. Alban's, The Grange.	Welwyn Rectory.	Reigate, Woodhatch Lodge.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
October 23	·11	·20	·14	·05	·04	·11	·05	·09	·11	·68	·02	..	·07	·05	·05	·04	·13	·05	·01	·08	·07	·07	·06	·06	·03
24	·80	·61	·59	·52	·67	·68	·74	·77	·72	·51	·56	·50	·47	·69	·54	·51	1·39	1·62	1·20	·50	·52	·57	·62	·61	·79
25	·02	·02	·03	·05	·02	..	·03	·01	·01	(·13)	·12	·05	..	·05	·03	..	·04	·11	·10	·01	·01	·05	·01	..	·07
26	·53	·52	·48	·30	·41	·48	·32	·44	·43	(·60)	·73	·39	·30	·37	·41	·35	·75	·95	·53	·42	·37	·42	·34	·12	·49
27	·22	·24	·19	·06	·08	·13	·24	·21	·34	·16	·17	·35	·33	·18	·09	·08	·20	·21	·47	·18	·19	·29	·12	·07	·26
28	·40	·51	·44	·48	·35	·39	·49	·63	·66	·64	·47	·68	·57	·52	·50	·41	·37	·43	·44	·43	·56	·62	·64	·57	·19
29	·16	·16	·16	·05	·04	·07	·13	·21	·14	(·24)	·16	·22	·07	·02	·03	·08	·24	·24	·28	·16	·12	·09	·05	·04	·20
30	·99	1·43	1·44	1·22	·70	·85	1·30	1·40	1·25	(·80)	·79	1·47	1·35	·94	·84	·72	·95	1·04	1·56	1·36	1·10	·95	·90	·68	1·11
31	·06	·06	·04	·03	·05	·04	..	·07	·04	(·10)	·01	·02	·02	·08	·09	·09	·04	·06	·01	..	·03	·02	·07	·12	·04
November 1	·15	·10	·06	·09	·27	·08	·13	·13	·11	·43	·18	·08	·08	·10	·08	·08	·17	·12	·10	·07	·15	·16	·14	·10	·19
2	·04	·08	·06	·08	·12	·08	·07	·02	·03	·06	·02	·02	·01	·05	·07	·05	·05	·05	·02	·02	·03	·01	·03	·04	·04
3	·35	·24	·23	·24	·04	·14	·29	·34	·24	·19	·12	·13	·10	·32	·22	·30	·21	·23	·29	·12	·17	·18	·12	·10	·06
4	..	..	..	..	..	..	..	..	·01	·02	..	·01	..	..	..	..	·01	..	..	..	..	..	..	·09	..
5	·04	·10	·09	·05	·02	..	·15	·07	·02	·04	·07	·03	·01	·03	·01	..	·04	·10	·21	·01	·12	·06	·01	·02	·09
6	·01	·01	..	..	..	..	..	..	·01	·01	..	..	..	..	..	·08	·03	..	·01	·01	..	..	·01	..	·01
7	·62	·62	·59	·62	·78	·74	·57	·78	·56	·48	·39	·45	·47	·67	·62	·70	·40	·45	·43	·56	·35	·37	·63	·44	·49
8	·07	·02	·03	..	..	..	..	·01	·02	·11	..	·02	..	..	..	·02	..	·06	·01	·01	·03	..	..	..	..
9	·11	·13	·14	·09	·04	·14	·15	·11	·18	·12	·18	·13	·09	·13	·09	·07	·22	·21	·15	·08	·11	·12	·08	·06	·16
10	·30	·12	·12	·20	·07	·12	·13	·18	·18	·21	·20	·12	·08	·14	·15	·09	·19	·17	·24	·13	·13	·15	·25	..	·15
11	·52	·49	·49	·52	·29	·54	·43	·47	·49	·83	·49	·43	·41	·46	·50	·55	·68	·62	·38	·46	·40	·47	·50	·45	·55
12	1·25	·82	1·11	1·26	1·01	1·22	·78	·64	·77	·92	·82	·55	·93	1·18	1·62	1·68	·80	·64	·66	·49	1·00	·95	1·04	1·25	1·40
13	·42	·47	·40	·47	·53	·47	·28	·25	·27	·73	·38	·22	·13	·40	·56	·55	·64	·58	·35	·17	·19	·26	·33	·34	·14
14	1·19	1·18	1·18	1·51	1·02	1·33	1·05	1·25	·78	1·33	1·04	·75	·65	1·51	1·02	1·21	1·11	1·18	·87	·59	1·16	1·39	1·40	1·40	·94
15	·08	·03	·01	..	..	·02	·15	·09	·09	·15	·17	·17	·09	·07	·02	·08	·20	·20	·11	·10	·11	·11	·08	·09	·26
16	·03	·04	·04	·02	·01	·03	·02	·02	·04	·08	·06	·05	·02	·02	·01	·05	·39	·28	·08	·02	·02	·01	·01	·01	·28
17	·01	·03	·02	·01	·01	·03	·03	..	·01	·02	..	·02	·02	·06	·06	..	·01	..	·03	·03	·06	·07	·03	..	·03
18	·01	..	..	..	..	..	..	..	·02	..	..	..	..	..	·01	..	..	..	·01	·01	..	..	..	..	·01
Total	8·49	8·23	8·08	7·92	6·57	7·69	7·53	8·19	7·53	9·59	7·15	6·86	6·27	8·04	7·62	7·79	9·26	9·60	8·55	6·02	7·00	7·39	7·47	6·66	7·98

(8) *Levels of the Flood of 1894 and Calculations as to the volume discharged.*

TABLE V.—FLOOD LEVELS OF THE RIVER THAMES. FURNISHED BY THE THAMES CONSERVANCY BOARD.

Name of Lock.	1774.	1809.	1821.	1852.	1875.	Nov. 1882.	Feb. 1883.	1894.	1894. Above the Summer Level at head of Lock.	
	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	in.
St. John's	..	..	..	..	..	..	..	237·08	3	3
Buscot	..	..	..	..	..	..	..	235·63	4	5
Eaton..	..	..	..	..	..	..	..	231·26	2	0
Radcot	..	..	..	..	..	..	..	225·40	3	6
Rushey	..	..	..	..	..	..	..	220·29	3	3
Northmoor	..	..	..	..	..	..	..	208·61	4	7
Pinkhill	..	..	..	..	..	..	..	202·80	3	0
Eynsham	..	..	..	..	..	..	..	200·25	3	10
King's Weir	..	..	..	..	..	..	..	195·39	1	10
Godstow	..	..	..	..	..	..	..	191·77	0	9
Medley	..	..	..	..	..	..	..	189·48	2	2
Osney	..	..	..	..	..	188·14	..	186·39	0	6
Iffley	..	..	..	..	..	182·41	182·25	182·79	2	10
Sandford	..	..	..	..	..	179·16	179·16	179·51	2	6
Abingdon	..	..	..	..	170·07	170·17	169·84	170·42	2	4
Culham	..	..	..	..	166·70	166·86	166·35	166·27	4	3
Clifton	..	..	..	..	159·86	159·87	158·37	160·79	6	10
Day's	..	..	..	..	..	156·55	154·79	157·35	6	8
Day's Lock House ..	..	..	157·05	156·05	155·68	..	..	..	..	6
Benson Lock ..	..	..	..	..	151·80	150·94	150·68	153·01	7	1
Cleeve	..	..	..	..	..	..	..	144·35	5	9
Goring	..	..	..	..	..	..	..	143·24	6	4
Whitchurch	..	..	..	..	..	135·70	134·86	136·20	5	3
Mapledurham ..	..	..	..	..	130·74	130·98	130·77	131·67	4	6
Caversham	..	..	..	..	..	124·04	123·88	124·96	4	6
Blake's	..	..	..	..	..	..	..	122·96	3	2
Sonning	..	..	..	..	119·54	119·31	119·31	120·16	4	8
Shiplake	..	..	..	..	..	113·94	114·11	115·30	4	6
Marsh	..	..	..	..	109·50	109·10	..	110·06	5	
Henley Bridge, above	..	109·81	..	..	..	..	..	108·73	..	
Henley Bridge, below	108·67	109·01	..	..	..	..	..	108·26	..	
Hambledon Lock ..	..	..	..	..	104·95	104·48	104·82	106·28	5	[illegible]
Hurley	..	..	..	..	99·21	98·99	99·07	100·07	3	[illegible]
Temple	..	..	..	..	..	96·50	96·83	97·97	4	[illegible]
Marlow	..	..	..	..	93·60	93·00	93·58	94·98	5	[illegible]
Cookham	..	..	..	..	87·03	87·17	87·33	88·13	5	[illegible]
Boulter's	..	..	..	..	82·16	81·87	82·20	83·18	5	[illegible]
Bray	..	..	..	..	77·27	..	..	78·31	8	[illegible]
Boveney	..	..	..	..	70·00	69·92	70·25	71·40	6	[illegible]
Romney	..	..	..	..	66·97	65·66	66·25	68·28	7	[illegible]
Old Windsor ..	..	..	..	..	60·99	61·19	61·27	61·91	8	[illegible]
Bell Weir	..	..	..	..	..	53·11	52·69	55·27	7	[illegible]
Penton Hook ..	..	..	48·01	..	46·81	..	..	47·64	5	[illegible]
Chertsey	..	..	41·46	..	41·23	..	..	41·43	2	[illegible]
Shepperton	..	..	39·26	..	37·48	38·37	38·62	38·55	4	[illegible]
Sunbury	..	..	33·64	..	31·08	32·13	32·96	34·42	7	[illegible]
Molesey	..	..	30·20	..	..	26·83	27·83	29·65	8	[illegible]
Teddington	..	..	23·09	..	..	19·39	20·13	22·14	6	[illegible]

United States, why should it not be done for the Thames? At Hunger-
l the streets were nearly clear of water on the morning of the 16th; at
ngdon the flood was highest in the afternoon of the 16th; near Windsor
on the 17th, but at Teddington it continued to rise until nearly noon on
18th. We do not presume to quote any rate of translation, but evidently
'as so slight that neither a telegraph nor even a horse was needed to have
rmed the inhabitants of E. Molesey of what was coming upon them.
f houses are to be built below flood level, surely the occupiers might be
ned when to vacate their ground floors and have the piano carried
tairs.

TABLE VI.—Rainfall and Discharge for the Flood of November 1894.

Date.	1. Quantity passing over Teddington Weir. Millions of gallons per day.	2. Rainfall over Watershed equivalent to figures given in column 1.	3. Mean Daily Rainfall over the Watershed.	Date.	1. Quantity passing over Teddington Weir. Millions of gallons per day.	2. Rainfall over Watershed equivalent to figures given in column 1.	3. Mean Daily Rainfall over the Watershed.
		in.	in.			in.	in.
tober 19	332·1	0·01	..	November 12	4,063·5	0·07	1·12
20	374·4	0·01	..	13	5,250·6	0·10	0·61
21	384·3	0·01	..	14	6,776·1	0·12	1·02
22	358·2	0·01	..	15	7,949·7	0·14	0·07
23	363·6	0·01	0·12	16	10,257·3	0·19	0·04
24	468·0	0·01	0·66	17	12,798·9	0·23	0·02
25	887·4	0·02	0·06	18	20,135·7	0·37	0·00
26	1,362·6	0·02	0·55	19	17,319·6	0·32	..
27	1,229·4	0·02	0·18	20	10,485·9	0·19	..
28	2,038·5	0·04	0·46	21	7,850·7	0·14	..
29	2,174·4	0·04	0·14	22	6,786·9	0·12	..
30	2,932·2	0·05	1·07	23	6,400·8	0·12	..
31	3,975·3	0·07	0·06	24	5,859·9	0·11	..
vember 1	4,783·5	0·09	0·19	25	5,215·5	0·10	..
2	5,064·3	0·09	0·08	26	4,195·8	0·08	..
3	5,022·0	0·09	0·16	27	3,504·6	0·06	..
4	4,743·0	0·09	0·01	28	3,141·0	0·06	..
5	4,462·2	0·08	0·05	29	2,925·9	0·05	..
6	4,338·0	0·08	0·01	30	2,705·4	0·05	..
7	3,416·4	0·06	0·57	December 1	2,592·9	0·05	..
8	3,331·8	0·06	0·05	2	2,425·5	0·04	..
9	4,119·3	0·08	0·11	3	2,333·7	0·04	..
10	3,839·4	0·07	0·14	4	2,285·1	0·04	..
11	3,772·8	0·07	0·47	5	2,226·6	0·04	..
					Total	4·01	8·02

'articulars of Maximum and Minimum Flow of the River Thames.

	Gallons.
mum average daily flow for 14 days at Teddington 'eir. (See *Report of Royal Commission on London 'ater Supply*, par. 78.)	281,000,000
age daily discharge during nine years, 1883-91	1,362,581,288

PARTICULARS OF MAXIMUM AND MINIMUM FLOW OF THE RIVER THAMES.

(Continued.)

	Gallons.
Maximum discharge in one day over Teddington Weir during flood (November 18th, 1894)	20,135,700,000
Ratios.	
Fourteen days' minimum to average for nine years	1 to 4·8
Fourteen days' minimum to maximum discharge of flood of November 1894	1 to 72
Average daily discharge for nine years to maximum discharge of flood of November 1894	1 to 15

DISCUSSION.

Mr. B. LATHAM said that he had been much interested in the paper which Messrs. Symons and Chatterton had prepared, and he hoped all the statistics given would appear in print in the *Quarterly Journal*, as much of the information afforded valuable records concerning floods in the Thames. It certainly appeared that modern floods were not greater than those in earlier years, although there was a popular belief that drainage and similar engineering works had increased floods. The records available, however, seemed to demonstrate that the reverse was the case. Mr. Brodie's account of the causes which produced the heavy rainfall which resulted in the floods was a useful contribution to the account of the floods in the Thames in November last year, and showed clearly that the excessive precipitation was entirely due to the movements of two secondary depressions.

Mr. R. W. P. BIRCH expressed his appreciation of the thorough manner in which the work involved in the preparation of the paper had been performed. He joined with Mr. Latham in entering a protest against the opinion which was popularly held that land drainage increased floods; such an idea was an utter fallacy. Probably the reason that people thought that floods were greater than in former years was due to the alteration in the character of many of the districts liable to be flooded, the localities which many years ago were meadow lands being now covered with dwelling houses, so the effects of a flood in such districts were more serious in modern times than formerly. Concerning the divergence between the line of mean hydraulic gradient and the water lines at various parts of the Thames (as shown in Mr. Chatterton's diagram), he said that such fluctuations were probably due to the nature of the soil which the river passed through, some being soft and some hard, and the bed of the river consequently not being equally parallel to that gradient in all places.

Major L. FLOWER, in supporting the remarks made by Mr. Latham and Mr. Birch concerning the effect of land drainage on floods, said that he could not understand how it could be supposed that land drainage caused floods, as the flow of water off undrained land must be more rapid than the flow from drained land. Floods were caused by excessive rainfall, on high ground, flowing into the rivers and swelling the stream. He thought that the differences between the dotted line and the flood level shown in red on the diagram were due, as Mr. Birch had said, to the variations in soil of the district and in the bed of the river.

Mr. E. K. BURSTAL said that he wished to emphasize the desirability of plotting the bed of the river on the diagram exhibited, as such information would be most valuable. He had been professionally connected with several engineering works in various parts of the Thames, and the paper had consequently considerable interest for him, as during the last November flood the copings of the new waterworks' filter beds at Oxford constructed by him were 2 ft. 4 ins. above the flood level, while at the Windsor Sewage Works on the Ham at Old Windsor the water was only one inch from the top of the copings of the precipitating tanks, the latter of these measurements not affording a sufficient margin for safety. He suggested that information concerning the changes which had

been made in the bed of the river by dredging operations should also be obtained, so that such changes could be taken into consideration when comparing flood records of past and present times. There was one point in the river between Abingdon and Oxford where a great improvement had been made by the removal of a ridge of rock which formerly obstructed the channel.

Mr. R. F. GRANTHAM said that he disagreed with the remarks which had been made that because floods were as high in past years as they are now, it was to be concluded that land drainage and improvements in arterial drains did not increase floods. It must be remembered that great improvements had been effected in the river valley, and in consequence the water was now able to pass away more easily than formerly. He quoted the following table of the height of floods above Ordnance datum in the Upper Thames Valley and its tributaries above Wittenham in the years 1872 and 1875, and also alluded to some flood marks made by the Ordnance Survey on bridges in the district named.

Locality.	1872–3.	1875
	ft.	ft.
St. John's Bridge, Lechlade	236·08	236·68
Radcot Bridge	225·71	226·55
Tadpole Bridge	217·67	218·02
New Bridge	210·38	211·10
Chequers Inn, Bablock Hythe	206·16	206·70
Swinford Bridge	199·45	200·26
Radley Railway Bridge	171·68	172·23
Kennington Railway Bridge	179·89	180·59
Medley Lock	188·96	189·36
Islip Bridge	194·67	194·94
Magdalen College, Oxford	185·34	185·76
Culham Railway Bridge, about 1½ mile above Long Wittenham	160·01	160·71

Rev. J. SLATTER said that the diagram exhibiting the longitudinal section of the Thames between Lechlade and Teddington was extremely interesting, but it might at the same time be misleading, as it must be remembered that the depth and volume of the river varied from mile to mile. For instance, between Wallingford and Reading the river nearly doubles in volume, and the late Rev. J. C. Clutterbuck had shown that this was due to the channel cutting through the chalk, and the river was thus fed from the springs. He pointed out that at Oxford, where the flood level seemed low, the observations were made on the river Cherwell at about a mile from its junction with the Thames, and so did not represent the condition of the Thames itself. Besides the length and depth, there were also these other essential elements in the treatment of the question, viz. the breadth of the channel and the velocity of the current. He considered that it would be easy for the Thames Conservancy to send warnings of impending floods to those likely to be affected thereby, and he thought that the Board should be strongly urged to undertake this duty. From personal experience, extending over a number of years, he knew that at Reading the river was usually 36 hours rising after a heavy rainfall. One cause of increasing the floods appeared to be that the water was kept in check till the mischief was imminent, and he thought that when the water was known to be rising, facilities should be afforded to allow it to pass away freely. Floods were of much less duration in recent years than in earlier times, and the water subsided in one-fourth of the time it formerly occupied.

Capt. D. WILSON-BARKER remarked that at Greenhithe no indications of the floods were discernible.

Dr. A. BUCHAN commented upon the great lack of information concerning the height of floods in earlier years, and suggested that a good deal of useful material concerning floods might be accumulated if careful inquiries were made of old people resident in localities liable to be flooded, and diligent search made for any marks upon buildings or bridges. Dr. Buchan quoted an instance in which a portion of a railway in Scotland had been destroyed by a flood, and said that at the time the railway was projected inquiries were made concerning the heights of floods, and one old shepherd pointed out a height to which the water attained when he was a "laddie" as the highest he had known. The height so

pointed out being remarkably high, the engineers discarded the shepherd's statement as being probably erroneous, and the railway was constructed, allowing only for a lower level as the maximum flood height. Forty years afterwards, a flood such as the shepherd had spoken of was experienced, and resulted in serious damage to the railway. Concerning the cause of the rainfall which gave rise to the floods of November 1894, he (Dr. Buchan) said that he remembered two marked cases of storms originating within the limits of the British Isles, and he would like to see the conditions of air temperature and humidity worked up in connection with the formation of such storms.

Mr. G. J. Symons, in reply, said that it was not easy to get at satisfactory evidence whether agricultural drainage did or did not increase floods, because it was impossible to be sure that the producing causes of any two floods were similar, and unless the causes were identical no fair comparison could be made. The height of the flood at Oxford, as shown on the longitudinal section, was supplied by the Thames Conservancy, and referred to the main stream of the Thames, but it agreed very closely with the height given in the table of the height on the Cherwell. The importance of the proper and systematic markings of flood heights could not be too earnestly urged upon the authorities, and it was difficult to understand why more was not done in that direction.

Mr. G. Chatterton said that the questions of the connection between agricultural drainage and floods had been carefully avoided in the present paper, it being considered that such matters could be more suitably discussed by the members of the engineering profession. Concerning the marking of flood heights, he understood it was the intention of the Thames Conservancy to suitably indicate the height attained by the flood of last November at the various points on the Thames, as shown in the longitudinal section. Mr. Slatter's idea concerning the method of getting rid of the excess of water would be quite impracticable, as the volume of water to be dealt with was so great. The amount of rainfall over the Thames Valley did not appear to be sufficient in itself to account for the November floods, and it would seem probable, in order to account for the present increase in the amount discharged from November 17th to 18th, of over 7,000,000,000 gallons, that there were certain obstructions by fences and the like which up to a certain period held up the water, but, suddenly collapsing, caused the water to rush with irresistible force towards the main body of the stream.

Mr. J. W. Restler, in a communication to the Secretary, furnished the following list of levels to which the water rose at various times between November 14th and 22nd, opposite the Southwark and Vauxhall Water Company's works at Hampton.

River Levels during Flood taken at Sunnyside, Hampton.
Ordinary Summer Level 21·92 ft. above Ordnance Datum.

1894.	Time.	Ordnance Datum.	1894.	Time.	Ordnance Datum.
		ft.			ft.
November 14	7.30 a.m.	25·30	November 16	2.0 p.m.	28·41
„ „	9.0 „	25·44	„ 17	7.15 a.m.	29·48
„ „	2.30 p.m.	25·45	„ „	4.0 p.m.	30·19
„ 15	7.30 a.m.	26·43	„ 18	7.30 a.m.	31·02
„ „	9.0 „	26·52	„ 19	9.15 „	30·48
„ „	3.30 p.m.	26·91	„ 20	9.0 „	29·10
„ 16	7.0 a.m.	27·82	„ 21	11.30 „	27·28
„ „	9.30 „	28·16	„ 22	9.0 „	26·30

The following levels were taken November 24th, 1894, in Stain Hill Park from marks left by the scum, &c. of the top water level:—

	ft.
Opposite Mr. Tatham's gate, "Homedale"	39·16
At No. 3 Kempton Park Villas, mark on glass in bay window ..	32·02

Note on the Barometrical Changes preceding and accompanying the Heavy Rainfall of November 1894.

By FREDERICK J. BRODIE, F.R.Met.Soc.

[Received May 7th.—Read May 15th, 1895.]

A RECORD of the disastrous floods which occurred over England in November last seems scarcely complete without some reference to the changes in barometrical pressure which preceded and accompanied the heavy rainfall. I have therefore drawn up a few brief notes on this subject, and have reproduced the Weather Maps for the close of the unsettled period, when the rainfall was heaviest and most general.

During September and the early part of October 1894, a drought prevailed over all the more western and northern parts of the United Kingdom, the greatest deficiency of rain being reported over the west of Scotland and the northern and central parts of Ireland. Applying the definitions commonly accepted for the driest portions of England (a practice that seems to admit of little defence in dealing with districts in which the average rainfall is two or three times as heavy), it appears that at several stations in the west of Scotland there was an *absolute* drought lasting for more than three weeks, while over a considerable portion of Ireland and Scotland there was a *partial* drought lasting from five to seven weeks. In isolated portions of the western and northern counties of England an absolute drought lasted for 15 or 16 days, while at Falmouth there was no rain between September 26th and October 18th—a period of 23 days.

After the middle of October, however, the weather underwent a complete change, and for the next four weeks the country was visited by a long succession of cyclonic disturbances, the centres of which travelled mostly in a north-easterly direction, either outside our western coasts, or directly over the United Kingdom. During the first 10 or 12 days of the period the most important depressions observed were:—

(1.) A system of moderate intensity, which advanced from the Bay of Biscay on October 19th, and which afterwards moved in an east-north-easterly direction across the south of England, and thence on to Denmark and the Baltic. During its progress, Easterly or North-easterly gales were experienced on many parts of our north-east and north-west coasts, and Westerly gales in the English Channel, with heavy rain over nearly the whole of Ireland and England.

(2.) A far deeper depression, with minimum readings below 28·7 ins., the centre of which travelled in a north-north-easterly direction across Ireland and Scotland on the 24th, and which afterwards passed on to Scandinavia and Northern Russia. The passage of this system was attended by strong gales from various quarters on nearly all our coasts, with very heavy rain in all the western districts, and, locally, at some of the southern stations.

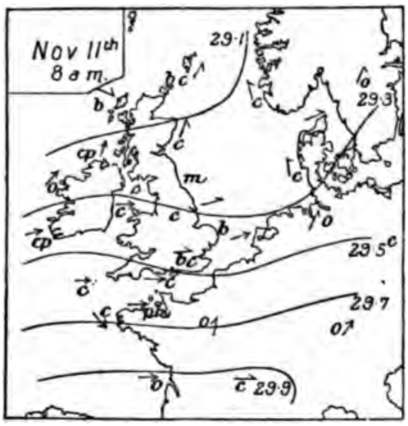
(3.) A rather shallow depression, which spread eastwards over Ireland and England on the 26th, but which gradually dispersed on the following day. In

this case gales were felt at the Channel stations only, but heavy rain again fell in many of our western and southern districts.

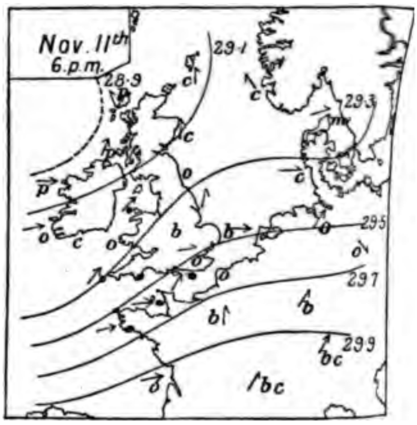
(4.) A series of small depressions,—subsidiary to a larger disturbance off our north and north-west coasts—which passed immediately over the kingdom on the 29th and 30th. These disturbances, though too shallow to produce much wind, were attended by further large quantities of rain over the southern parts of Ireland and England, the falls being in some cases excessively heavy.

Before dealing with what may be described as the crucial period in the history of the floods, viz. the four days commencing with November 11th, it will be readily gathered from the foregoing remarks that the latter half of October was characterised by unusually bad weather, especially in the more western and southern parts of the United Kingdom, where the rainfall was exceptionally large. The soil was, in fact, thoroughly saturated, and in the worst possible state for meeting the tremendous excess of rain which occurred after November 10th.

On the morning of the 11th (see Map 1), a depression was passing away in a north-easterly direction to the northward of our islands, the barometer was rising a little on our south-west coasts, and fine weather prevailed over a considerable portion of the United Kingdom. The wind was from the Westward or South-westward, and blew freshly or strongly in the west and south.



Map 1.

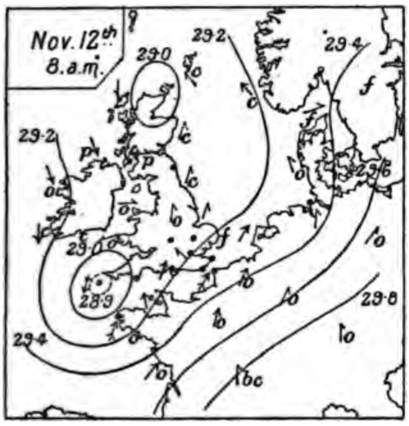


Map 2.

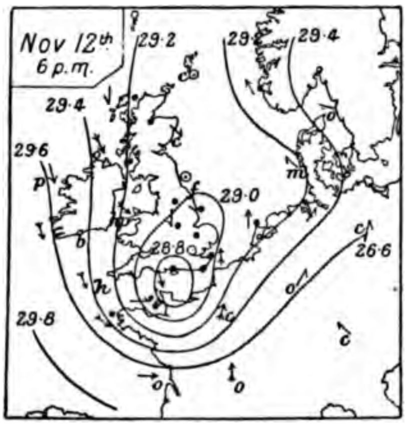
A black dot denotes that rain was falling in that locality at the hour of observation.

Map 2, for 6 p.m. of the 11th, shows that by that time a double set of changes was in progress. Off the west of Scotland there were decided indications of the advance of another large depression from the westward, while on our south-west coasts the downward trend of the isobar marked 29·3 ins., coupled with a brisk fall of the barometer at Scilly and a backing of the wind there from West to South-west, seemed to show that a secondary disturbance was approaching the more southern parts of the Kingdom. On our north and east coasts the weather remained fine, but in the western parts of the English Channel, as well as in the north-west of France, steady rain was falling.

The chart for the following morning (Map 3) showed that in the course of the night the main disturbance had travelled north-eastwards, its centre being shown at 8 a.m. over Caithness. In the south a very decided change had occurred, and from an examination of the automatic records made at Valencia, Scilly and Falmouth (access to which has been kindly granted by the Meteorological Council), it is quite clear that a secondary depression of considerable depth had been rapidly formed slightly to the northward of the Scilly Islands. At Valencia the barometer fell very gradually, and the wind veered from South-west to North, while at Falmouth the mercury went down quickly after midnight, the changes in wind direction both there and at Scilly being sudden and very peculiar. By 8 a.m. on the 12th the centre of the secondary depression lay a little to the south-eastward of the Scilly Islands, the wind being strong to a gale from the



Map 3.

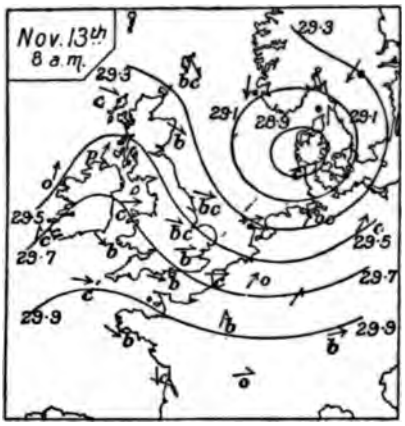


Map 4.

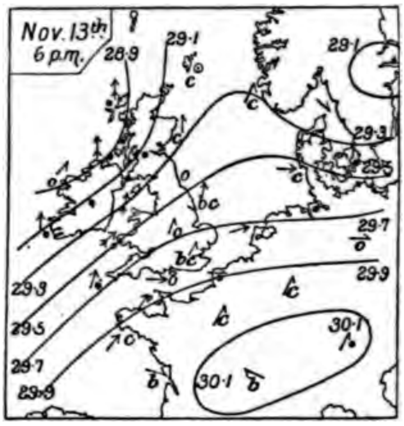
Southward or South-westward at the Channel Stations generally, but from the Northward at Scilly. Steady rain was now falling at nearly all stations in the south of England as well as in the north of France. Later in the day the main depression over the north of Scotland entirely dispersed, while the secondary in the south moved steadily eastwards along the Channel. By 2 p.m. the centre of the latter system lay about midway between Prawle Point and the Channel Islands (the minimum pressure occurring at Falmouth at 1 p.m.), while at 6 p.m. it was situated a little to the southward of the Isle of Wight (Map 4). In the south-west of England the weather now showed some improvement, but in all other parts of our southern districts rain continued to fall steadily, while in the course of the evening, when the centre of the disturbance travelled north-eastwards, lightning, thunder and hail were experienced over our south-eastern counties.

By 8 a.m. on the 13th (see Map 5) the depression had reached the Danish coasts, and the weather over England had become fine and bright, with moderate to fresh breezes from the westward. In the extreme west of our Islands, however, the isobars were again trending downwards, a decided fall

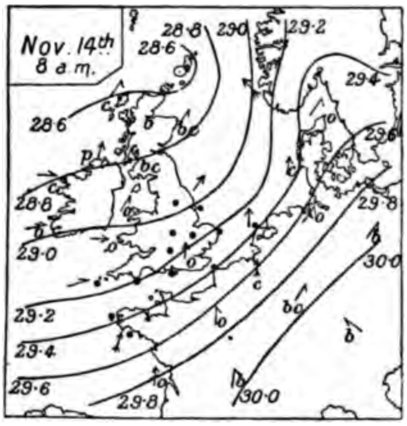
of the barometer being reported in the west of Ireland with a return of the wind to the Southward and with an increase of cloud. Later on the barometric fall became very rapid, and by 6 p.m. (Map 6) a large depression was seen to be approaching our north-west coast. Southerly and South-westerly gales and rain were now reported at nearly all our western stations.



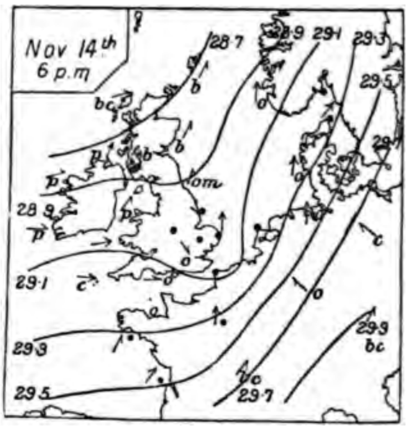
Map 5



Map 6.



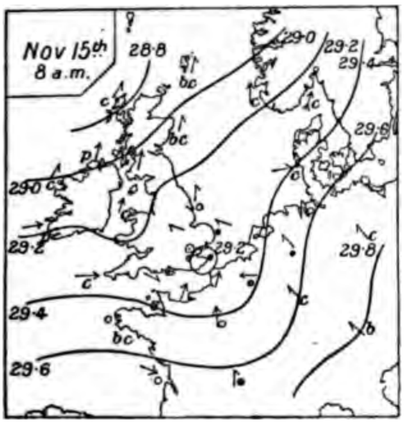
Map 7.



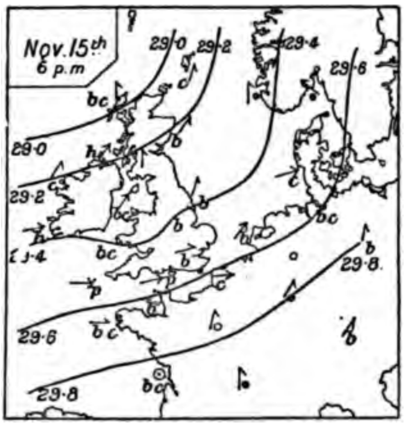
Map 8.

The chart for next morning (Map 7) was somewhat similar to that for 6 p.m. of the 11th. In the course of the night the main depression had travelled north-eastward, and by 8 a.m. of the 14th it was passing away to the northward of Scotland. In the neighbourhood of the Bristol Channel, however, there were again some indications of the formation of a secondary disturbance, the compression of the isobars due to this small system resulting in further gales from the South and South-west over the Channel. Steady rain had now set in over nearly the whole of England, the weather in Ireland and Scotland being comparatively fine, though showery in places.

Later in the day the secondary disturbance underwent a gradual process of development (though not to anything like the same extent as in the case of the former disturbance), and moved steadily eastwards across the southern parts of England, its centre being shown at 6 p.m. (Map 8) over the south-eastern counties. During the afternoon a severe gale from the southward was experienced on the Kentish coast. In the course of the ensuing night the depression appears to have made very little progress, and at 8 a.m. on the 15th (Map 9) the centre remained over the south-east of England, steady rain being still reported at many of the eastern and southern stations. Later on, however, the system moved north-eastwards and dispersed: the weather in the south improved decidedly, and the period of heavy rainfall was practically at an end.



Map 9.



Map 10.

The conclusion of the whole matter seems to be that the torrential rains of November 11th-14th were caused by two secondary depressions, each of which developed a certain amount of intensity. In the case of the former the depression grew to such an extent as to entirely overshadow in importance its primary,—a feature not uncommon in the history of such systems. In the latter case the secondary never attained very much prominence, the cyclonic circulation round its centre being only partially developed. The formation or growth of a barometrical depression is ordinarily attended by heavy rains, and the wetness of the weather at this time was, therefore, by no means surprising. The barometrical changes seem to furnish, however, but a very inadequate explanation of the exceptional character of the rainfall, so that in this, as in many other cases, the meteorologist is forced to admit that there are factors in the weather of which at present very little is accurately known.

A NATURAL THERMOMETER.

By Rev. FENWICK W. STOW, M.A., F.R.Met.Soc.

[Received March 27th.—Read May 15th, 1895.]

Most people will remember that the frosts of May 21st, 1894, and the two following days, were remarkably severe for the time of year; and did much damage to the foliage of forest trees, and to all fruit trees that were then in blossom.

A few days after the frost, I noticed that some large spreading horse-chestnut trees near the village of Thoralby, and close to the stream known as the Bishopdale Beck, presented a curious appearance. The foliage of the lower branches was quite blackened, but halfway up less injury was done; while at the top, in spite of the greater exposure to radiation, from which the lower boughs were comparatively sheltered, the leaves remained tolerably green. It would have been difficult to show by a photograph the contrast between the appearance of the higher and lower branches, as the leaves which were blackened by frost remained on the trees, and would have too much resembled those which were still green.

In the case of ash trees, however, a singular phenomenon presently showed itself, which I was able to photograph. Ash trees in this part of Wensleydale and Bishopdale, at an elevation of 500 to 800 feet, usually come into leaf at the beginning of June.

In the spring of 1894 they were unusually forward. On May 21st they were all in bud, and a few warm days would have covered them with leaf.

The effect of the frost on the higher ground was to retard their coming into leaf; but the buds were uninjured, and before the middle of June they were all in pretty full foliage. It was otherwise with those which stood in the wide and flat valley of Bishopdale, below Aysgarth Vicarage.

On June 27th a large ash tree in the very lowest part of this valley showed scarcely a single leaf, the buds having been quite destroyed. Crossing the valley by the road, which rises very slightly, I observed other ash trees which showed leaf at the top. Further on, the leaf extended half-way down the trees, and at last, on approaching the village of West Burton, on the opposite side of the valley, the ashes were clothed with foliage all over. Close by was the garden of Mr. J. C. Winn, where a minimum temperature of 23° had been registered in the May frosts in a screen of the Stevenson pattern—or rather, in the improved screen adopted by this Society. At the Vicarage, which stands between the main valley of the Yore and Bishopdale, and 180 feet above the latter valley, the minimum was 28°.

As the leaf buds had not been destroyed near Mr. Winn's garden, which is some 25 feet above the lowest part of the valley, it is evident that the temperature which destroyed the leaf buds must have been lower than 23°.

There are many other ash trees in the valley, and, as far as I could see, all, according to their respective position, presented similar appearances. I did not see any tree but that one absolutely devoid of leaves. But there was only one near it, and that one was higher and therefore had leaves at the top.

It is scarcely necessary to observe that the local depression of temperature near the surface of the ground in a valley depends upon the dryness of the air. If the air is moist and the night mists or frost-haze have extended some distance up the hillsides, the minimum will not be very low, but nearly uniform, within the limits of the mist, owing to the obstruction to radiation caused by the mist, and to the setting free of latent heat by its formation. But if it is very dry, and the dew point excessively low, the local depression of temperature in the lowest part of the valley may be very great. I used to keep a minimum thermometer in an extemporised screen not far from this unfortunate ash tree, and in the winter of 1881 it registered $-13°$. The late Mr. Whipple kindly ascertained for me the error of the thermometer, which at 0° was 0°·9, so that the correct temperature was $-12°$, 9° lower than at the Vicarage. In the winter of 1879-80 Colonel Ward placed, at my request, a registering thermometer in a hollow place near the bottom of the valley at Rossinière, in Switzerland, where he then resided. He obtained the astonishing record of $-37°$, and for a week the average minimum of $-25°$. The record at his residence, only 100 feet higher, was $-12°$, showing a difference of 25°. But I do not think that the air is ever dry enough in the British Isles to admit of so great a local depression as this.

During the frosty period of May 1894 the air was dry, but not unusually so. I should have expected the local depression of temperature in the valley to be 6° or 8°: that is to say, the minimum to be from 22° to 20°. This agrees with the conclusion derived from the indication of Mr. Winn's thermometer, namely, that the temperature which destroyed the leaf buds was lower than 23°.

It would seem that the indications of the ash trees, turned into Fahrenheit's scale, recorded a temperature of about 20°.

I may add that in the severe frost in February of this year the air was not particularly dry. The frost-haze, as shown by the rime on the trees, extended at some time in the night of the 7th as far up as the Vicarage, where the lowest temperature was $-2°·1$. A little lower down, on the south side of the valley of the Yore, and a furlong from the Vicarage, $-4°·2$ was registered. Mr. Winn's thermometer registered $-6°$. The difference therefore was not great.

HOURLY VARIATION OF SUNSHINE AT SEVEN STATIONS IN THE BRITISH ISLES.

By RICHARD H. CURTIS, F.R.Met.Soc.

(Plates 7-18.)

[Received February 16th.—Read June 19th, 1895.]

The present is, I believe, the first attempt which has yet been made to deal with the subject of the hourly variation of the duration of sunshine over a considerable area of the British Isles, by means of hourly tabulations of the records. The short time which has elapsed since the introduction of the sunshine recorder, as part of the instrumental equipment of meteorological observatories, has made it impossible to deal with the subject earlier, and, indeed, it is not suggested that the period of 10 years which is now available is sufficiently long to yield other than approximate values ; I believe, however, that it is long enough to enable one to obtain a fair idea of the character and extent of the hourly variations for the months and seasons, and it is in this tentative way that the following remarks are offered.

The data used will be found in the tables of mean results which are about to be issued by the Meteorological Office, as an appendix to the volume of *Hourly Means* for 1891, and I am indebted to the Meteorological Council for permission to use these tables before they are actually published.

The instrument used at each of the stations dealt with is Sir G. G. Stokes' modification of Mr. Campbell's original recorder, introduced in 1880, in which the sun's rays are focussed upon a strip of card, where they burn a trace representing the sun's path across the heavens. The record obtained is therefore one of *bright sunshine* as indicated by the intensity of the solar *heat* rays, and it affords no measure of the sun-*light*, or of the *actinic* rays, as apart from those of heat.

Unless the heat rays have, when focussed upon the card, sufficient power at least to discolour it, no record at all is made, and this point is therefore the inferior limit at which the instrument will register ; on the other hand, when insolation is strong, and the solar rays are unobstructed, a clear burn of greater or less width is made right through the card, and therefore between these limits the instrument affords a rough scale of the intensity of the sun's heating power. In tabulating the records, however, no attempt was made to take *intensity* into account; any visible trace, however faint, was measured, and the measurements combined without distinction with those obtained from stronger records.

Until the sun has reached a certain altitude above the horizon its rays have not sufficient power to affect the card, and thus no trace is ever made within the 15 minutes immediately following sunrise or preceding sunset. A slight film of cirrus haze also, or even a slight haziness of the lower atmos-

phere, although it may not prevent the sun from shining with sufficient brightness to cause faint shadows to be cast, will yet frequently suffice to intercept enough of the heat rays to stop the record. The low ground mists, more commonly experienced at sunrise than at sunset, have the same effect; but the amount of trace lost through them will obviously depend in

Campbell-Stokes Sunshine Recorder.

some degree upon the position occupied by the recorder, which if placed near the ground, as at Stonyhurst, may be expected to lose more from this cause than if it be placed high above the ground-level, as at Aberdeen; the character of the surrounding district is also a factor of much importance in this connection.

The following particulars as to the exposure and position of the instruments at the observatories now dealt with ought to be given; the stations are arranged according to latitude.

ABERDEEN.—The instrument is placed upon the Cromwell Tower of Aberdeen University, at a height of 75 feet above the ground, where it has a good exposure at all seasons of the year. To the eastward the sea is not far off, whilst the city of Aberdeen is about a mile distant to the south. To the west and north the ground rises, with hills in the distance.

GLASGOW.—The Observatory is in a western suburb of Glasgow, the neighbourhood of which city must necessarily affect the amount of sunshine recorded. The instrument is 24 feet above the ground, and has an unobstructed horizon for sunshine at all seasons of the year.

ARMAGH.—The height of the instrument above the ground is 38 feet, and its horizon is perfectly free from obstruction, except for a few minutes at about 4 p.m. during April and August, and to a less extent during May and September also. The Observatory is situated on the top of a hill, a quarter of a mile to the north-eastward of the city, and about 100 feet above the general level of the surrounding country, the character of which is pastoral and well wooded.

STONYHURST.—The recorder is only 4 feet above the ground, and the sun's rays are cut off from it by buildings for a very short time at sunrise in spring, and at sunset in midwinter. The exposure is otherwise good, and the surrounding country, although hilly, is very open.

VALENCIA.—Throughout the ten years the recorder was at the old Observatory, it was fixed 7 feet above the ground, but its exposure for sunshine was good throughout the year. The Observatory was quite close to the shore, and although the surrounding country is hilly, it is not wooded, and the hills are too remote to interfere with the record.

KEW.—The instrument is placed 47 feet above the ground, on the parapet of the Observatory, which stands in the Old Deer Park to the north-west of the town of Richmond, and about three-quarters of a mile from it. The River Thames is less than a quarter of a mile away to the west, while to the north and east the level ground of the park extends for a considerable distance. There are no buildings near the Observatory in any direction, but it is possible that a few minutes of early and late sunshine may be cut off from the recorder in mid-winter by isolated trees.

FALMOUTH.—The instrument has occupied two positions during the ten years. Until 1885 its height above the ground was 50 feet, but in that year the Observatory was removed to a new site, and the height of the instrument was changed to 84 feet. In both cases the exposure for sunshine was a perfect one, the observatories standing on high ground nearly 200 feet above the mean sea level, and quite above the chief part of the town of Falmouth. The surrounding country is hilly and slightly wooded, whilst to the southward the open sea is only about a mile distant.

Obviously, with so limited a number of stations as seven, scattered over an area comprising 7° of latitude and 10° of longitude, it would be useless to attempt to draw any conclusions as to the general distribution of sunshine over the British Isles. The following observations on the tables are therefore offered without pretending to regard the respective stations as representing more than the districts immediately surrounding each.

There are two ways in which the records may be considered. Either the number of hours of sunshine actually observed may be dealt with, in which case, when comparing the records of different stations with each other, it becomes important to bear in mind the varying lengths of time that the sun is above the horizon of each place, and which is, of course, dependent upon the latitude of the station and the season of the year; or the observed amount of sunshine at a station may be considered with reference to the amount which would have been received there, supposing the sun to have shone without obstruction during the whole time it was above the horizon, and that its whole duration was recorded. In the latter case the *observed* amount would be expressed as a percentage of the *possible* amount. Both these methods have advantages of their own, and therefore the results in the tables are expressed in both ways, wherever possible.

Turning to the figures, it is of interest to notice that upon the whole there is a fairly close agreement between the means for the two five-year periods into which they are grouped. From this fact it may be inferred that the ten-year means, with which alone it is now proposed to deal, approximate with a fair degree of closeness to the means which a longer period would have yielded had the figures been available.

Taking first the average daily duration for the whole year, we find that Falmouth is decidedly the most sunny station of the seven, having a daily average amount of sunshine of just over 4½ hours. This amount is half-an-hour more than that recorded at Valencia, the station with the next highest average, and three-quarters of an hour more than Kew, which holds the third place. Of the remaining four stations, Aberdeen, the most northern, but at the same time a coast, station, with 3·64 hours, has more than either Stonyhurst or Armagh, both inland stations; whilst Glasgow, with only 3 hours per diem, or about a quarter of its possible amount, has the smallest

record of the seven, a result to some extent due, without doubt, to the nearness of the Observatory to some of the large manufacturing works with which the city of Glasgow abounds.

Or, if we deal with these figures, as representing percentages of the possible duration at the respective stations, we find that the order in which they succeed each other as regards their comparative sunniness is unchanged. The 4½ hours at Falmouth represent 37½ per cent. of the possible amount, while the 3 hours per diem at Glasgow represent but 25 per cent. of the possible amount for that place.

If we group the months so as to represent the four seasons of the year, taking December to February inclusive as winter, March to May as spring, June to August as summer, and September to November as autumn, it will be found that during the winter quarter the south-western stations again appear as the most sunny of the seven. Falmouth and Valencia have in this three months each an average daily amount of 2 hours, while Aberdeen, notwithstanding its high latitude, occupies the third place with a mean duration of rather less than 1¾ hours per diem. Armagh, however, with just over 1½ hours per diem, has during this quarter decidedly more sunshine than the remaining three stations, both Stonyhurst and Kew having about a quarter-of-an-hour per diem less, whilst Glasgow has the smallest daily average of just under one hour.

In the spring quarter, with the increase of the sun's declination, a great increase in the average daily amount is, of course, noticeable, but the relative positions of the stations as regards the length of their daily average is not much changed. The two south-western stations have again the longest duration, but Falmouth, with nearly 5·7 hours, has begun to take the lead, although the duration is only one-tenth of an hour per diem more than that at Valencia. Kew, notwithstanding its proximity to London, which might have been expected to militate against its record of sunshine, now comes next to Valencia, although its mean daily amount is three-quarters of an hour less. Aberdeen, Stonyhurst and Armagh follow in the order named, the mean duration at Aberdeen being 4·66 hours and at Armagh 4·53 hours, and Glasgow is again lowest with an average duration of only 4·12 hours per diem.

In the summer quarter Falmouth and Kew both show an increase in the mean daily duration of more than an hour and a quarter, and whilst Falmouth, with a mean daily duration of 7 hours, is still the most sunny place, Kew comes next to it with a mean of 6·1 hours. Valencia shows only the trifling increase of a tenth of an hour upon its average for the spring months, and is the third upon the list; whilst Aberdeen and Stonyhurst are not far below it, with nearly 5½ hours each. The increase in the duration at Glasgow from the spring quarter is nearly three quarters of an hour, whilst the increase at Armagh is barely two-tenths of an hour, and as a consequence the former station shows a higher record than the latter, the 4·72 hours duration at Armagh being the smallest recorded at any of the seven stations. It is a peculiar fact of some significance, that the increase in the daily duration

shown by the two Irish stations from spring to summer should be so small, whilst it is so decided at each of the other five.

In the autumn three months the relative distribution of the daily duration reverts again to very nearly that of the spring, but the average amounts are in every case much smaller, owing to the shorter length of the mean day. Falmouth has an average of 3·64 hours sunshine per diem, which is more than half an hour above the duration at Valencia and Kew, the figures for which two stations are now almost identical. The mean duration at Aberdeen is 2¾ hours, and Stonyhurst and Armagh have both of them a tenth of an hour less, the difference between the autumn and summer duration being less at the latter station than at any other. Glasgow, with only 2·1 hours per diem, again falls into its usual position with the smallest average amount of any station in the series, an amount which is only a tenth of an hour above the average duration at Falmouth and Valencia during the winter quarter.

Turning now to the daily means for the several months, we find, as might have been expected, that January and December are the most sunless months of the year. At no station is there much difference between them, but the smallest mean daily duration of sunshine occurs in December at every station except Falmouth, where January is the less sunny month of the two. In January the mean daily duration varies from seven-tenths of an hour at Glasgow to rather more than 1·8 hours at Valencia; Stonyhurst has one hour, and the daily amounts at the remaining four stations—Kew, Armagh, Falmouth, and Aberdeen—show a progressive increase, in the order named, of between one and two tenths of an hour. After January the mean daily duration increases quickly except at Kew, where the increase shown in February is only slight, and is less than that of any other place. In March, however, this defect is made up, and from thence to May the mean daily amount continues to increase each month with fair regularity at all the stations; Valencia and Falmouth keep very close together, with daily amounts considerably greater than those of any other station; Aberdeen, Armagh, Kew, and Stonyhurst are also very similar, whilst Glasgow has uniformly the least amount of all.

At Valencia, Kew, Stonyhurst, and Armagh, the maximum duration is reached in May, the daily mean amount varying in the order named from 6¾ hours to 6 hours. At Falmouth and at the Scotch stations the increase is maintained, although in a less degree, until June, when the mean duration at Falmouth reaches 7¼ hours, at Aberdeen 6¼ hours, and at Glasgow 5·6 hours. From May to June the decrease shown at those stations which attain their maximum in the earlier month is not great, but from June to July the decrease is not only general, but at every place, except Kew, very large. At the Irish observatories it is about 1½ hours, at the Scotch one hour, and at Falmouth and Stonyhurst about three-quarters of an hour; at Kew it is but a tenth of an hour, and this place is peculiar for the very gradual decrease shown through the three summer months—June to August. At most of the stations, however, this rapid decrease is not maintained. At Falmouth the

duration in August is but a tenth of an hour less than in July, and at Valencia it is actually a tenth more, whilst at Glasgow and Aberdeen the decrease from July to August is less than half an hour; at Armagh also the rate of decrease slackens, and continues to do so until September, but at Stonyhurst there is no check in the rate after June.

From August to the end of the year the rate at which the mean daily duration decreases, although rapid, is less so than was the increase during the first five months of the year. At the English and Scotch stations the diminution is fairly uniform, and at Falmouth and Kew remarkably so, Kew having throughout rather more than half an hour per diem less sunshine than Falmouth. The Irish stations are peculiar in having a more gradual rate of decrease, and especially is this the case at Armagh. As a result, although in August the mean daily duration at Armagh is less than 4 hours, which is nearly half an hour less than that of Glasgow, in November it is still nearly 2 hours, and exceeds Glasgow by an hour. The fact that in July and August the mean duration at Armagh is less than that at any other station, not excepting Glasgow, is one of some significance.

It will now be interesting to consider these same figures when expressed as percentages of the possible duration at the respective observatories, because their meaning then becomes to some extent modified by the season and latitude of the station. Judged in this way, by what may be termed their capabilities, we find that in January Aberdeen and Valencia, the most northern and most western stations, are practically alike, with 22 per cent. of sunshine; Falmouth and Armagh, although two very dissimilar stations as regards their physical surroundings, have each about 18 per cent.; Kew and Stonyhurst, both inland stations, each get about 13 per cent.; whilst Glasgow, with only 9 per cent., is the least favoured station of the seven.

The values for the subsequent months follow in a general way the course of the mean hourly amounts already referred to, but they present more sharply some features which were made less apparent by those figures.

Taking first the values for Falmouth, which are generally higher than those for any other place, the monthly increase in the percentages is uniformly about 8 up to April, then only 3½ in May, and less than 1 in June. In July the percentage falls from 46 to 43, but it rises again in August to nearly 47, which is a trifle above that of June, and is the maximum of the year. Thence it decreases less rapidly than it increased in the spring to 21½ in December. The most noticeable point here is that the slight diminution shown in the mean hourly duration between July and August becomes a decided increase, when it is expressed as a percentage of the possible amount, and exhibits in a striking manner a summer minimum and second maximum. Comparing these values with those for Valencia, the station which most nearly resembles Falmouth in its surroundings, we notice that after January there is an almost perfect similarity between them up to April, when they begin to diverge greatly from each other. The maximum, 43 per cent., is reached in May, and is followed by a decrease to 32 in July;

in August there is a rise of 4 per cent. to a second maximum, and then again a fall to the close of the year; but it is remarkable that in September and October the decrease is only slight, and this with the sharp decrease in June and July are the two principal points of difference between the values for the two stations.

The values for Kew, Stonyhurst, and Armagh, three inland stations, are not very dissimilar during the first five months of the year, the principal differences being that Stonyhurst in February shows a greater increase in its percentage than the other two, and that at Kew the increase in March is very large; but at each place the maximum is attained in May, after which the march of the phenomenon at the three stations becomes altogether dissimilar. At Kew the percentage decreases from the maximum of 41¼ in May to a summer minimum of 38 in June, after which it increases to a second maximum of 41 in August; then follows a steady decrease to 14¼ in December. At Stonyhurst the maximum of 39 in May is succeeded by a steady decrease to 33 in July, and less abruptly to 31 in September, after which it falls quickly again to 12 in December; but although the decrease of the percentage is retarded in August, there is no rise to a second maximum, and in this respect Stonyhurst is alone. At Armagh the maximum is 37½ per cent. in May, and this is followed by a drop similar in amount to that at Valencia, which brings it to 27 in July, the fall at the two Irish stations being greater than is shown at any other place. In August, however, there is a further slight fall instead of a rise, and the second maximum does not occur until September, after which there is a decrease of about 5 per cent. by November, which is far less than elsewhere, followed by a rapid decrease to 15¼ per cent. in December. The two Scotch stations have also their maximum in May—36¼ at Aberdeen, and 33 at Glasgow—with a summer minimum in July and a second maximum in August; then at Aberdeen, as at Valencia, the decrease in the percentage is slight until October, after which it falls away rapidly, whilst at Glasgow the decrease is more rapid and uniform from August to the close of the year.

We come now to the distribution of sunshine throughout the day as exhibited by the mean hourly amounts, and the figures will probably be best dealt with if each observatory is taken separately. It is, however, necessary to bear in mind here that the comparative shortness of the period over which the observations extend is more likely to make itself felt detrimentally when the figures are broken up into such small divisions as hours, than when they are grouped to represent the daily amounts for the months and seasons, which have already been dealt with, and any conclusions drawn can therefore only be regarded as more or less provisional in character.

The most prominent feature brought out at all the stations is the rapid increase in the mean hourly amount of sunshine recorded during the first few hours following sunrise, and the even more rapid falling off again just before sunset. Speaking broadly, this rapid increase in every month of the year seems to cover about two to three hours, and the decrease rather less, the changes in the hourly amounts during the remainder of the day being of

much smaller amplitude. Bearing in mind that the record is one of sun heat, it would seem that the infrequency of sunshine at these relatively early and late hours is not so much owing to greater cloudiness as to the fact that insolation is cut off by the greater extent of the lower atmosphere through which the solar rays have to pass, and which just after sunrise and before sunset is more charged with condensed vapour than is the case during the intervening hours of the day.

Taking first the most northern station, *Aberdeen*, the values for the different months show a great similarity in the daily march of the phenomenon (Plate 7). The most sunny hour is always at, or very close to, noon, and after the early hours there is no indication of any part of the day being especially favoured as regards sunshine. In the winter the increase in the mean amount goes on steadily to the maximum, and at once falls off again as regularly; but in the spring and summer months the maximum amount is maintained over a longer period, and there is but little difference between the mean amounts for some hours before and after the time of actual maximum. April and June are exceptions to this rule, to the extent that the later hours of the day are decidedly more sunny than the corresponding hours in the morning; but this is not the case in any marked degree in any other month. Taking the means for the whole year, the maximum frequency occurs at noon, and the hours following noon have a slight advantage over those preceding it. The average amount of sunshine per hour in the sunniest part of the day varies from about three-tenths of an hour in winter to very nearly half an hour in May; in June and August it also approaches 50 per cent., but in March, April, July and September it is only about four-tenths of an hour. For the whole year the average amount of sunshine in the 60 minutes, from 11.30 a.m. to 0.30 p.m., is 0·39 hour.

The next station in order of latitude is *Glasgow*, the results for which place are very different from those yielded by Aberdeen (Plate 8). In the winter months the hourly increase is more gradual, and the maximum, though not so large as at Aberdeen, is reached less abruptly. The afternoon hours are also, as a rule, decidedly more sunny than those of the morning, and except in the winter the sunniest period is generally about 2 p.m. March and April, however, offer marked exceptions to this rule, as the maximum hourly amount occurs then at 11 a.m. and noon respectively, after which time the sunshine decreases steadily till 3 or 4 p.m., and then more rapidly to sunset. The values for the months May to September show a marked contrast in the very gradual increase hour by hour up to the maximum, and the rapid decrease after the maximum had been passed. Taking the mean hourly amounts for the year, the greater frequency of sunshine in the afternoon is well shown. The mean amount of sunshine per hour in the most sunny part of the day is less than two-tenths of an hour in November December and January; in February, March and October it amounts to about three-tenths of an hour; in July, August and September to rather under four-tenths of an hour; and in April, May and June to between four and a half and five-tenths of an hour; for the whole year it slightly exceeds three-tenths of an hour.

At *Armagh* the hourly variation is in some respects peculiar during several months of the year (Plate 9). In January, February, and March the hourly duration increases rather quickly to a maximum just before noon, after which it falls off again more gradually than it rose. March has a less rapid increase, and exhibits a decided minimum at 2 p.m., rising again at 8 p.m., and then decreasing till sunset. In April, May, and June the hourly increase is rapid and is not followed by any very decided maximum, the amount of sunshine experienced showing but very slight variation till within a few hours of sunset, when the decrease is as rapid as was the morning increase. In July the maximum occurs as early as 9 a.m., after which it falls away to noon, which is a less sunny hour than 7 a.m. From noon to 5 p.m. the average amount of sunshine does not vary much, and it then decreases quickly to the hour of sunset. In August both the increase and decrease are more gradual, and the maximum does not occur till 1 p.m., and the remaining months of the year exhibit an hourly variation not very dissimilar to that of the corresponding months at the beginning of the year, the only prominent feature being a secondary minimum in October at 1 p.m. The maximum amount per hour varies from about a quarter of an hour in January and December to rather less than half an hour in May, and it is only in April, May, and June that it ever exceeds four-tenths of an hour. In July, for the greater part of the day the amount per hour is only equal to that found in February and November. Dealing with the whole year, the sunniest part of the day occurs just before noon, and the average amount of sunshine is three-and-a-half-tenths of an hour.

Stonyhurst is the station next in order of latitude, and it is also, like Armagh, an inland station (Plate 10). In the first two and last four months of the year the distribution of sunshine throughout the day follows a fairly even course, the maximum occurring in each case at about noon, and being preceded and followed by a pretty uniform increase and decrease in the hourly amounts. In March and April, however, the most sunny hour is 11 a.m., the hourly amount increasing quickly up to that hour and then falling off steadily till the evening. In May and June 1 p.m. is the sunniest hour, with 4 per cent. more of the possible amount of sun than noon, the falling off in the latter month being very gradual until after 4 p.m., while the increase in the morning hours is less rapid than in May. In July and August this retardation of the morning increase is still more marked than in June, and the maximum does not occur until 2 p.m., after which, in July, it is maintained till 4 p.m. before it begins to fall quickly, whilst in August the falling off begins at once, and 3 p.m. has 5 per cent. less sun than 2 p.m. The maximum hourly duration varies from two-tenths of an hour in January and December to five and a half-tenths of an hour in May. February has a tenth of an hour more sun at noon than has January and the March maximum shows a similar increase upon February. From April to September, with the exception of May, the maximum hourly amount is from four and a half to five-tenths of an hour; October is a tenth of an hour below September, and November, with two and a half-tenths, is a tenth less

than October. For the year the maximum hourly duration is less than four-tenths of an hour, and occurs at noon and 1 p.m.

Valencia, the next station south, is one of the most sunny of the seven (Plate 11). In the winter months of November, December, and January the maximum hourly duration occurs at 11 a.m., and a rapid increase throughout the morning hours is followed by a much more gradual falling off during the afternoon; in February, however, this latter feature is less pronounced, and a more uniform increase and decrease is exhibited throughout the day. In March it again becomes very marked, and the maximum at 11 a.m. is followed by a very steady but marked diminution till 4 p.m., and then by a rapid fall to sunset. It is worthy of note that in a less degree this is a feature of the diurnal variation in March at all the stations, with perhaps the exception of Aberdeen and Falmouth. In April little difference is shown in the hourly amounts from 9 a.m. to 1 p.m.; but in May and June the hourly duration goes on increasing till 1 p.m. before the maximum is reached, the hours following noon being much more favoured as regards sunshine than the corresponding hours before noon. In July the chief feature is the very gradual increase in sunniness from 6 a.m. to noon; but the three following months exhibit upon the whole a fairly uniform increase and decrease, with but little change during the middle hours of the day. The winter months show high maximum hourly durations:—In December it is nearly three-tenths of an hour, and in November, January and February from three-and-a-quarter to three-and-a-half-tenths. March has half an hour, and the three following months about half-a-tenth more, but July, August and September reach only about four-and-a-half-tenths as the maximum, and October rather less. For the whole year the maximum hourly duration is about four-and-a-quarter-tenths of the total possible, and the diurnal variation follows a fairly uniform course from sunrise to sunset, the maximum occurring at noon.

Kew is only about halt a degree south of Valencia, but being an inland station it exhibits some strong contrasts to the latter (Plate 12). The chief of these are the relatively small amount of insolation in winter, and the more uniform diurnal distribution exhibited in most months of the year. In January, February, November, and December the maximum occurs at noon or 1 p.m., but in January, and still more in February, the steady hourly increase is somewhat checked in the morning at about 11 a m. In March the maximum amounts to about 15 per cent. more than in February, and occurs at 11 a.m., and is followed by a slow but decided falling off till 3 p.m., after which hour the decrease becomes rapid till sunset. In April, 10 a.m., with 47 per cent. of the possible amount, is the sunniest hour, the average duration in the succeeding hours being fairly uniform, but decidedly less than at 10 a.m. May exhibits a very uniform variation in the diurnal distribution, with the exception of a slight check at 9 and 10 a.m., the maximum at 11 a.m. being followed by a slight but steady falling off till 4 p.m. In June, however, the maximum does not occur till 1 p.m., and the diurnal variation is again fairly steady. July exhibits a remarkable falling off in the mean amount recorded

during the afternoon hours, more especially after 1 p.m., and the hour of 3 p.m. is less sunny than it is in either of the two preceding or succeeding months. In August and September there is a fairly uniform increase and decrease shown, but in October the increase in the daily amount goes on steadily to the maximum at 1 p.m., after which the average amounts fall away very abruptly to sunset. From May to September inclusive the maximum hourly amount is about one-half of the possible amount. For the whole year the increase and decrease in the mean hourly duration is very uniform and steady, rising to 40 per cent. of the possible amount at noon and 1 p.m., and showing slightly higher percentages in the afternoon than in the corresponding morning hours.

Falmouth is both the most southerly and the most sunny of the seven stations, and in some respects its diurnal distribution of sunshine is different from that of any of the others (Plate 19); with hardly an exception its maximum hourly amounts are larger, and as compared with Valencia, the station to which it most nearly corresponds as regards its geographical situation and physical surroundings, it exhibits a more uniform diurnal variation, the maxima being in most months of the year deferred till much later in the day, while there is an entire absence of the marked decrease of sunshine in the afternoon hours which is so striking a feature of Valencia in some months. The least sunny month is January, when the maximum hourly amount is but a quarter of an hour at noon, the amounts recorded for 10 a.m. to 2 p.m. being but slightly less. In February the maximum hourly amount increases to nearly four-tenths of an hour at 11 a.m., and again there is but little falling off till 2 p.m. In March there is a marked slackening of the hourly increase at 9 a.m. and 10 a.m., but this is followed by a quick rise to the maximum at noon; it is noteworthy, however, that the maximum, which is less than half-an-hour, is considerably below that of Valencia for the same month, and also that there is no indication of the rapid falling off in the hourly amounts during the hours immediately succeeding which is shown by the Valencia means. In April the maximum increases to nearly five-and-a-half-tenths of an hour, and the p.m. hours are shown to be decidedly more sunny than the a.m. In May the hourly amounts increase steadily till 2 p.m., and do not begin to fall off much until after 4 p.m., the maximum being nearly six-tenths of an hour. In June the march of the mean hourly amounts is very similar to that shown in May, but the maximum occurs still later in the day, at 4 p.m., and slightly exceeds six-tenths of an hour. July is a decidedly less sunny month than either May or June, and a marked check in the increase of insolation is shown during the middle hours of the day; the maximum, which occurs at 3 p.m., amounts to only five-and-a-half-tenths of an hour. August is again a very sunny month, the maximum, which occurs at 2 p.m., equalling that of June, but it is ollowed by a more rapid falling off in the amounts during the two or three hours immediately succeeding. September brings a large decrease in the amount of sunshine; the maximum occurs at 1 p.m. and only slightly exceeds half-an-hour, there is, however, not much variation in the amounts

recorded from 9 a.m. to 4 p.m. In October the maximum occurs as early as 10 a.m., after which the hourly amounts fall away slightly till 2 p.m., and then more rapidly to sunset. November and December both exhibit a very uniform increase and decrease in the mean hourly amounts, and in both cases the maximum is reached at noon. Taking the means for the year, the hourly march of insolation is very uniform; the maximum is reached at 11 a.m., and is maintained till 2 p.m., the afternoon hours having rather more sun than the corresponding hours of the morning. The maximum amounts to four-and-a-half-tenths of an hour.

DISCUSSION.

Mr. C. HARDING said that this paper dealt most completely with sunshine statistics, the data being discussed in regard to the monthly, seasonal and hourly variation, and the results possessing additional interest as the first of the kind ever published. Concerning the rise in the p.m. portion of the mean daily curve of sunshine at Glasgow as compared with the portion before noon, he thought that possibly the drift of the smoke from the various factories which abounded in that city was to some extent the cause of the difference between the morning and afternoon sunshine. It was comforting to note that Kew, in spite of its proximity to our smoky metropolis, came out with such good results.

Mr. H. S. WALLIS said that it would be interesting to see how far the discussion of sunshine observations at additional stations would modify or confirm the results shown in this paper. The increase in the amount of sunshine during the afternoon hours at Glasgow appeared, as Mr. Harding had suggested, to be due to the situation of the Observatory in relation to the manufactories, the Observatory being to the west, and the manufacturing district in the east of the city; so that during the morning hours the smoke cloud would be between the sun and the recorder, while in the afternoon the sun would be shining from the westward, and no smoke would intervene. These artificial conditions, and also the case at Armagh, where the shadow of the anemometer shaft caused an interruption in the record, suggested that too great a hurry should not be evinced in accepting the anomalies in the results given in this paper as representing physical facts.

Mr. F. C. BAYARD inquired whether any explanation could be offered which would account for the general flatness of the diurnal curves at all the stations between 10 a.m. and 3 p.m. He suggested that a description of both the Campbell-Stokes pattern of sunshine recorder and what was known as the "universal" recorder should be added to the paper. A difficulty often experienced with the "universal" pattern was that the ball was liable to slightly shift from a rigid position through the clamps with which it was held becoming loosened, the instrument thus being put out of focus. He had heard, too, that during heavy gales the ball of the Stokes' pattern had been blown off its pedestal at places where the recorder was in an exposed position.

Mr. W. H. DINES thought that Mr. Curtis had partly explained why the curve was almost flat in the middle of the day, when he stated that the instrument recorded sun heat rather than sun light. During the middle of the day, when the sun was high, no doubt a trace was made whenever the sun was shining; but in the two or three hours after sunrise and preceding sunset there was but little heat to spare; and an accidental occurrence, such as the paper being wet, or a strong wind tending to keep the paper cool, would stop the registration. He thought that in the summer the early morning and late evening were more cloudless than the middle of the day, and it would be very interesting if anyone present could enlighten them as to the behaviour of the photographic recorder in that respect. He had lately been trying a new form of sunshine recorder, which registered electrically on a clock drum. He found that if he adjusted this instrument so that it recorded the early morning and late evening sunshine, it also recorded in the summer during the day, when the sun was only just visible through clouds; but if it were adjusted so that it would record sun-

shine at midday only when the sun was shining clearly, then it failed to record within an hour or half-hour of sunrise or sunset.

Mr. W. B. TRIPP said that of the two forms of sunshine recorders at present in use, one gave indications of the heat rays, and the other of the chemical rays of sunshine; a third instrument to record the rays of light appeared to be desirable.

Mr. G. J. SYMONS said that he knew very little concerning sunshine recorders; but, so far as he was aware, no attempt had yet been made to record the light or yellow rays of the solar spectrum, the red rays being of course registered by the burning recorders and the violet rays by the photographic recorders. He thought it was a matter for congratulation that the first elaborate discussion of sunshine observations should have been read before the Society, and it was something to be proud of to know that England possessed the most splendid organisation of sunshine observations to be found anywhere. It was of course perfectly clear that when the observations extended over 20 years instead of 10, many of the irregularities at present noticeable in the curves would disappear. As regards the increase in the afternoon sunshine at Glasgow, he was disposed to agree with the explanation suggested by Mr. Harding and Mr. Wallis; but the curve for Falmouth exhibited a very similar excess, which certainly could not be so easily explained away, as there was no accumulation of smoke at the Cornish town as there was in the Scottish city. The flatness of the curve during the middle of the day, to which attention had been drawn, was doubtless due, as Mr. Dines had pointed out, to the greater power of burning which the sun's rays possessed during the midday hours. He had always thought that the records of those now old fashioned instruments, solar radiation thermometers, were really dependent upon the sun's altitude, and the sunshine records appeared to be in a somewhat similar position. He had been wondering whether it would be possible to reduce all the sunshine observations to a hypothetical sun altitude.

The Hon. F. A. R. RUSSELL ventured to add the suggestion that this inquiry might with advantage be extended so as to include the relation of sunshine to the different winds in each locality. The results of such an investigation might be to afford, especially for certain hours of the day, some idea of the absorption of the sun's heat by the atmosphere under various conditions of wind.

Mr. T. W. BACKHOUSE remarked that the results of the paper seemed to show the effect of mist and haze on the registration of sunshine. He inquired whether the amount of cloud exhibited corresponding diurnal variations to those shown in the curves of sunshine.

Mr. F. GASTER said that many of the irregularities exhibited in the sunshine curves were without doubt due to lack of sufficient data upon which to base an average, the curve for the year being calculated from a considerable number of observations presenting a much smoother appearance than those for the individual months. Some interesting facts had been brought out as a result of investigation into sunshine records in the British Islands, and it was now known that coast stations, especially in the south, were sunnier than inland stations, and that the winter sunshine along the south coast was in excess of that recorded in other districts. The exposure of a station was an important factor in the comparison of sunshine observations, as it would be obviously unfair to compare the records from an instrument situated in a valley with those from one on a hill. In connection with the effect of smoke upon the recording of sunshine, it is not sufficient to consider whether an Observatory lies near a city, but the direction of the prevailing wind must also be taken into account. Kew and Greenwich, which are respectively situated west and east of London, are good examples of the effect of the wind upon the drift of the smoke, a Westerly wind carrying the smoke towards Greenwich, and so lessening the amount of sunshine recorded, while an Easterly wind exercises the same effect upon the Kew sunshine records. The flattening of the diurnal curve of sunshine in the middle of the day appeared to be due to the greater amount of cloud which it was well known prevailed during those hours.

Mr. W. MARRIOTT said that Mr. Ellis and the late Mr. Whipple had each communicated papers to the Society on the diurnal variation of sunshine at Greenwich and Kew respectively, but Mr. Curtis's paper was the first attempt to similarly discuss the sunshine records at several stations distributed over the British Isles. It would be interesting if the investigation could be carried still

further, and some person with a large staff and plenty of funds at his disposal, or such individual observers who might feel so disposed, would discuss the hourly sunshine records in relation to direction and force of wind, temperature, pressure, and humidity, particularly the last named, as atmospheric moisture appeared to exert considerable influence upon sunshine records. When inspecting the Society's stations, he had frequently found the sunshine recorders to be imperfectly adjusted, the "universal" pattern being particularly liable to derangement owing to the glass sphere slipping out of position, the screw clamps which hold it in its place being liable to become loose. A ready method of testing the position of the glass ball was to pass a sovereign between it and the metal frame in which the card was placed; if the coin went round quite evenly the ball would be in the centre of the frame and in good focus. It would be interesting to have a comparison of sunshine records upon a hill and in a dale. Great difficulty was often experienced in securing a perfectly free horizon for a sunshine recorder, and the height of the instrument above the ground varied considerably at different stations. Some recorders were placed on the top of towers or lofty buildings, while others were exposed only a few feet above the ground, where the records were liable to be influenced by morning and evening mists. The physical features of a district required to be taken into account when comparing sunshine records. For instance, Ventnor, owing to its sheltered situation under the undercliff, which rose to a considerable height to the north-west, had the evening sunshine considerably diminished, and it would not, therefore, be comparable with, say, the records for Eastbourne, where the instrument had an uninterrupted horizon. Valuable and interesting results would doubtless be obtained if observations with recorders placed at various elevations above the ground in an open situation were carried out with the object of determining what effect, if any, elevation above the earth's surface had upon the registration of sunshine.

Mr. G. J. Symons, referring to Mr. Backhouse's inquiry, said that Mr. Glaisher had fully discussed the question of the diurnal variation in the amount of cloud, and the results of his investigation were to be found in the *Diurnal Range Tables*, which Mr. Glaisher published many years ago.

The President (Mr. R. Inwards) said that with regard to the general question of sunshine recording, he would like to know whether any Fellow of the Society had attempted to make direct observations of the effect of sunshine on the growth of plants. He remembered that at the Society's Exhibition of Instruments in March 1891 an ingenious apparatus for weighing growing plants was shown, the arrangement being, he believed, but a carrying out in detail of the suggestions of the Dutch author, J. Ingen Housz, who wrote in 1729. He (Mr. Inwards) would also like to know whether any observations had been made as to the effect of wind on the sunshine recorder itself, as it was easy to see that there must be great differences of exposure to wind at the various stations.

Mr. R. H. Curtis, in reply, said it would be of great interest to study the diurnal variation of sunshine in connection with the diurnal variation of temperature, wind-force, rainfall, and barometrical pressure, to each of which he thought it would show some degree of correlation. In connection with such a study it was most important to bear in mind the physical features of the district represented by the record, because there could be no doubt but that these exercised a very direct influence upon the amount of sunshine experienced, as they did also upon the march of the other phenomena which he had named. The necessity for a perfect exposure was emphasised by the peculiarity in the Armagh record, to which he had referred. There were districts in which it was impossible to obtain a perfect horizon for the recorder owing to hills, but such hills formed a natural feature which affected the sunshine "capability" (to repeat the term he had used in the paper) of that particular district, and as such it had to be taken into account. It was not, however, to such obstructions that he now referred, but to others of a local and artificial character, such as trees and buildings, and which affected only the actual place of the recorder, and not in any way the district it professed to represent. The shadow cast on the card at Armagh was but for a few minutes each day, and only during a few weeks in spring, and again in autumn. It was by no means easy to detect it by inspection of the records, and it would scarcely make itself felt in the mean daily amount

for the months affected; but it became very conspicuous in dealing with the hourly amounts, and under some circumstances might easily prove very misleading. Some speakers had apparently thought that the flattening of the curves in the middle of the day indicated an increased cloudiness then, but that was not necessarily so; it showed an equal distribution of sunshine over the middle hours of the day, but that might conceivably represent *less* cloud in the morning and afternoon rather than *more* cloud at midday. He did not consider that the smoke of Glasgow would wholly account for the greater sunnyness of the afternoon as compared with the morning hours, although doubtless it did so to a great extent. The prevailing winds would blow from the observatory towards the city, and the diurnal increase of wind-force, which corresponded very fairly with that of sunshine, would tend to clear the smoke away from the observatory, and to that extent might be held to account for the phenomenon; but a similar phenomenon was shown at Falmouth also, where smoke could not be possibly made to explain it, and therefore he was led to believe that smoke was not the only cause involved in it. With reference to Mr. Symons' remarks as to a "hypothetical altitude" as a standard of intensity, he might mention that occasionally in winter the burn made upon the card was equally as broad as in summer; wind-force he did not think influenced the burn at all. On the whole, he was of opinion that the Stokes' form of instrument was the best, especially if improved in one or two details, as could easily be done; to the "universal" form he had some objections, and he had several times found these instruments out of proper focus.

THE FREQUENCY, SIZE, AND DISTRIBUTION OF HAIL AT SEA.

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When reading the Hon. Rollo Russell's comparatively recent work *On Hail*, it occurred to me that the author, in the absence of either positive or negative information, had fallen into an error in his treatment of one branch of the subject, namely, that of the occurrence of hailstorms out on the ocean. Having had much to do with maritime weather records, I felt sure that a general examination of some of them would reveal facts at variance with the conclusions arrived at in the book referred to.

The references to falls of hail are confined almost wholly to those observed on land, the numerous authorities quoted evidently contenting themselves with land records, and Mr. Russell has thus been unwittingly led to suppose that hail is essentially a land phenomenon.

On pages 57 and 58 there is an extract from the *Philosophical Magazine* giving a brief account of "a shower of ice in irregular pieces" which lasted three minutes, at a distance of about 300 miles south of the Cape of Good Hope. Page 94 contains a reference to showers of hail "in the Atlantic"

in December 1869, but no information is given as to whether the falls were north or south of the Equator, in mid-ocean or close inshore.

These constitute the sum total of the instances of ice or hail on the water, and when we remember that the extracts cover a period of more than two centuries, it is not surprising that Mr. Russell should have decided, in Chapter VI., "Summary of Characteristics of Hailstorms and Hailstones," page 154, that "in mid ocean it [hail] is uncommon;" and again in Chapter VII., "Conclusions," we have the upshot of the discussion of a multitude of theories and conjectures resolving itself into a law which declares (page 202) that "the equability of the ocean temperature, and the usual absence of comparatively very cold masses of air at a high level, will rarely allow the development of great hailstorms over the open sea." It really looks from these extracts as if we ought to regard the only two falls mentioned as being merely accidental circumstances which should not have occurred in a properly constituted oceanic atmosphere. The book contains nothing to show that mariners have supplied evidence proving that hail is a stranger to them, neither are there any data to support the notion as to "the usual absence of comparatively very cold masses of air at a high level" over the ocean.

I am not going to propose any theory regarding hail at sea; my object in contributing this paper to the Society is simply to place on record a few facts gleaned from original and authentic sources which will satisfy Mr. Russell that his theories cannot be justified.

As is well known, mariners have for more than 40 years been registering systematic weather observations for the Meteorological Office, and several thousands of the logs are stored in Victoria Street. The information on which this paper is based has been obtained from a few of these manuscript volumes, the Meteorological Council readily granting me permission to inspect the logs for the purpose.

To discuss the entire collection would manifestly be beyond my powers, and for the immediate object in view such an elaborate inquiry is quite unnecessary. For testing the frequency, what I have done is this. The logs of 18 vessels visiting the southern oceans were taken in the order in which they came to hand, and without any attempt at selection for the sake of the quantity of observations they may contain. The volumes related to the years 1871, 1875, 1876, 1877, 1878, 1880, and 1881. Going through the column headed "Weather," the entries of the letter "h" were noted. Of the 18 vessels one proved to be a steamer running between Lisbon and Rio de Janeiro, no hail being registered. Three of the observers made use of "h" to represent both "hail" and "haze," and were consequently disqualified. One of these gave as many as 55 entries of "h," 30 of which were undoubtedly hail, because they were confirmed by definite statements in the space for remarks, but the remaining 25 were too doubtful for use. I had consequently the logs of 14 ships to deal with. A dozen of them sailed down the South Atlantic for Asiatic, Australian, or New Zealand ports, the other two going round Cape Horn. All of them experienced hail, the 12

which went into east longitude recording, between the meridian of Greenwich and the 180th meridian, and at the ordinary four-hourly periods, 177 entries of "h," or an average of 15 each, one ship having 29, another 30, and a third 32. In the more open part of the Indian Ocean, between 30° E. and 120° E., with only two or three infinitely small specks of islands in the whole space, 118, or 67 per cent., of the hail observations were noted. As ships do not usually go very far south in crossing the Indian Ocean, nearly the whole of the hail recorded was on the equatorial side of the 47th parallel, and about a sixth of the total number of observations on the northern side of 40° S.

Five of the ships in the South Pacific, between 180° and 70° W., recorded hail 38 times, most of them on the polar side of 50° S., but a few to the northward of 40° S.

The logs also contain observations of hail in the North and South Atlantic, and the North Pacific, the 14 observers recording on their out and home passages a total of 114 days with hail. If we accept the theory which tells us not to expect hail at sea, an average of eight days per ship per voyage is very high indeed. But I have glanced through scores of other logs, and I believe I am justified in saying that the results deduced from these chance 14 registers give a very fair general average, hardly any of the ships escaping hail at some stage or other of a voyage in the open southern oceans, some registering it very much more frequently than any of those included in the foregoing summary. Thus, one observer on the way to New Zealand and home entered "h" 66 times—outward, 5 in the North Atlantic and 16 in the Indian Ocean; homeward, 31 in the South Pacific, 9 in the South Atlantic, and 5 in the North Atlantic. Another had 21 entries between 4° E. and 49° E., in 37° S. to 39° S.; while an observer giving weather entries regularly every two hours recorded hail 85 times while running from 10° to 139° E., in 44° to 48° S.; another as many as 96 times within 16 days between 51° E. and 165° E., in 43° S. to 49° S. Of this very large number, 12 were underlined once, 12 twice, and one thrice, the underscoring denoting intensity. Further, 45 of the entries were within five days, 10 being heavy, and 12 very heavy. On the homeward run across the South Pacific the same observer gave 20 entries of hail in five successive days, so that we have a single observer with 116 records while running about two-thirds the distance round the southern hemisphere.

It must be borne in mind that these records are merely from chance visitors to any particular locality, and this fact must be taken into account in any attempt at comparison between sea and land data. The great, the remarkable, frequency of hail in the Indian Ocean is, however, fully confirmed by the log of H.M.S. *Erebus* for the period of the stay in Christmas Harbour, Kerguelen, from May 12th to July 20th, 1840. Out of the 70 days hail fell on 24; in May 10, in June 11, and in July 3, there being in all 64 entries of hail, the weather records being hourly as a rule. Is there any fixed station in Europe which can, for its worst hailstorm year, equal this mid-ocean return?

In the foregoing I think I have brought forward quite enough evidence to negative the assertion that hail at sea "is uncommon."

Nor is the undoubted frequency of hail the only feature worthy of attention, for, contrary to another portion of Mr. Russell's theory, great hailstorms are often met with on the open ocean. My difficulty has not been to discover accounts of severe storms, but to select a few typical examples of what we may regard as not uncommon occurrences. Figures have already been given showing the proportion of moderate, heavy, very heavy, and excessively heavy hail experienced in the South Indian Ocean during a run from west to east. Taking another register in the same neighbourhood, and for another year, I find that out of 14 days, between 59° E. and 136° E., in 44° S. to 47° S., hail fell on 10 days. On one day there was a considerable fall of hail and snow; later the observer remarked: "Several times during the night the decks were covered an inch deep with hail and snow;" next day hail fell most of the time, snow or hail falling for three hours almost without cessation. A few days after great quantities of hail fell in frequent heavy squalls.

A Fellow of this Society, Capt. A. W. Jeffery, of the s.s. *Ptolemy*, experienced a severe hailstorm on March 14th, 1883, in 41° N., 43° W., fairly in mid-Atlantic. "11.45 p.m. squall force 9 lasted 40 minutes, and wind flew to the North-west. During this squall the lightning was very vivid, and the hailstones of an immense size, so much so that the helmsman could not hold the wheel, and the ship's head was turned to the southward for 30 minutes till the hail ceased."

Capt. Peebles, of the four-masted barque *Tweedsdale*, on August 17th, 1883, in 39° S., 21° E., reported:—"9.30 p.m. a thunderstorm burst over us, incessant lightning seemed darting through the gear, peal after peal of thunder shaking the whole ship. For about 15 minutes had a tremendous fall of hailstones as large as pigeons' eggs."

On the barque *Margaret Wilkie*, Captain Gibbs reported a hailstorm on October 26th, 1875, in about 37¼° S., 22° E. At first the stones were from the size of a pea to that of a horsebean, but afterwards they became larger and thicker.

Capt. Gray, on the barque *Shun Lee*, August 25th, 1881, in 34° S., 28° W., noted:—"7.30 p.m. sky commenced to cover with a dense nim. cloud from South-west, and which by 8 p.m. hung like a dense pall, making an intense darkness. As soon as well overhead, hail as big as large peas came down in a perfect avalanche, covering the poop about 2 inches in a few minutes. As it passed it changed to rain." When commanding the barque *Speranza*, Capt. Gray had a fall of large hailstones in February 1873, in 57° S., 76° W., and on May 22nd, 1873, in 44° S., 77° W., "had some hard hail and sleet squalls, some of the hailstones as big as a nut. Had very heavy hail and sleet squalls at short intervals, but at 3 p.m. had a most terrific one. Kept away with reefed topsails on the cap, and then it seemed as if it would bury the ship. Had a similar one, not so heavy, at 6 p.m." Again in the following November he had a heavy fall of *lumps* of jagged-edged pieces of ice, some of them an inch long, in 42° S., 60° W.

In six days in April, while sailing along the 50th parallel of south latitude between 173° E. and 158° W., Capt. J. P. Holdich, R.N.R., of the ship *British Envoy*, gave 24 entries of "h." At 7 p.m. on April 22nd, in 159° W., he had a tremendous fall of hail, the poop deck being covered to a depth of 3 inches in 20 minutes.

On the homeward passage from San Francisco, in May 1882, Capt. Hughes, of the ship *Laomene*, gave 13 entries of hail in 15 weather observations, from 8 p.m. 10th to 4 a.m. 13th, between 82° W. and 67° W. in 56° S., remarking that heavy hail fell about every three-quarters of an hour, and lasting 10 or 15 minutes, the falls covering a period of 41 hours, from noon 10th to 5 a.m. 13th. Again from 9 p.m. 23rd to 8 a.m. 25th, in 47° S., 46° W., to 44° S., 41° W., he had nine entries of heavy hail which fell in squalls every half or three-quarters of an hour.

Another vessel rounding Cape Horn in August 1872 spent 15 days between 56° S., 67° W., and 49° S., 80° W., with 25 entries of hail, the observer remarking, "One thing I consider worthy of note, that we have had no really heavy rain, but certainly a great quantity of hail and thick weather."

In January 1860 Capt. Sweet, of the ship *Pizarro*, had hailstones as large as small nuts in a heavy fall in 43° N., 14° W.; and in June 1868 Captain Banner, of the barque *Lady of the Lake*, had very large hailstones in a thunderstorm in 40° S., 89° W.

Capt. Atkinson, of the *Priorhill*, in April 1888, had 12 entries of hail in 43° S., 100° E. to 110° E., remarking that the hailstones were the size of small marbles.

On May 14th, 1873, in 36° N., 71° W., Capt. McRitchie, of the ship *Assaye*, had "one of the most awfully grand thunderstorms," with heavy squalls of rain and hail, some of the hailstones being as large as walnuts. In the previous October, in 38° S., 2° E., he had had hailstones as large as marbles.

Capt. James Gales, of the *Florence Nightingale*, in March 1857, in 56° S., 66° W., had two kinds of hail falling, one small and round, the other large and angular, and striking with great force. Near the same position, 57° S., 64° W., his brother, Capt. Isaac Chapman Gales, in October 1868, had "sharp showers of large snowballs, not hail proper."

On November 15th, 1863, Capt. Kerr, of the *Jane Henderson*, in 35° S., 26° E., remarked, "At 6.30 p.m. an immense waterspout formed suddenly in the west, about two miles distant, and bore rapidly down upon the ship. She was steered to the south in the hope of clearing it, but it approached within three ships' lengths and discharged pieces of ice upon our decks, about 2 inches square (not in balls, but flat). This was immediately followed by a terrible flash of lightning and sharp rattling thunder, a deluge of rain, and a furious squall."

Not far from the same spot, 35° S., 24° E., Capt. Wight, of the *Dunalistair*, on July 5th, 1876, had the lower part of a waterspout cross his bows, his weather column showing very heavy squalls, with thunder, lightning, hail, and rain, from 8 a.m. to 8 p.m., noting in the remarks that "the hail was like a ball of clear ice."

In May, 1891, Capt. Randall, of the *Laomene*, in 39° S., 29° E., had a terrific thunderstorm from north-east, with showers of hail and ice.

A tremendous thunderstorm broke over the ship *Martaban*, Capt. Gun, on August 16th, 1872, in 45° S., 121° E. "The hail and snow seemed to come in lumps, striking the face like snow balls."

Capt. Wilson, of the barque *Horsa*, experienced a violent squall, with lightning, on November 11th, 1884, in 41° S., 49°E. "It brought a perfect torrent of pieces of ice like splinters ½-in. in length."

The Society's *Quarterly Journal*, Vol. XX. page 172, contains an extract from the Meteorological Office log of the s.s. *Anglian* relating to a heavy ha iland thunderstorm in the Bay of Biscay, the hailstones being as large as walnuts, many an inch and two of them 1¼ in. in diameter.

I might, however, fill a whole volume with notices of very heavy, terrific, or tremendous falls of hail far away from land; of stones varying in size from large peas to walnuts and pigeons' eggs; and of pieces of ice up to 2 inches square—but the examples quoted amply suffice to prove that great hailstorms on the ocean are not such altogether exceptionally rare events.

Another branch of the question is that of the distribution of hailstorms at sea. Mr. Russell is evidently content with the view expressed by Prof. Fritz, which he quotes at page 74—"Hail is confined to middle latitudes," the maximum hail-fall being between the latitudes of 40° and 60°—of course, on land.

So far as my knowledge of the contents of the meteorological logs goes, I have no hesitation in asserting that on the open ocean hail is not only exceedingly common in occurrence, but also more frequent and in greater

quantities than on land, the region of abundant hail being on the polar side of the 35th parallel of latitude in both hemispheres, the logs yielding records in abundance. Between the 35th and the 30th parallels there is a perceptible falling off in the frequency, but still, when we consider the latitude, it is by no means uncommon for vessels to be overtaken by more or less heavy hailstorms. Within these limits, and only on the most cursory inspection of a number of logs, I have noted scores of observations of hail, but I will only refer to a few of them to show the various localities in which they have been met with, as well as to prove that they are not trifling falls.

In a strong Northerly gale on February 7th, 1876, Capt. Gillmoore, of the ship *Melpomene*, had heavy hail entered at 8 a.m. and noon, in 34¾° N., 36¼° W., air temperature 50½°, sea 61½°.

Captain Rowsell, of the R.M.S. *Tagus*, experienced a heavy hailstorm on August 8th, 1888, in 34¾° S., 58° W. (entrance to the Rio de la Plata), the thunder and lightning being incessant, and the hailstones of the size of eggs.

During a severe Westerly gale on July 15th and 16th, 1855, Capt. Cowell, of the ship *Anna*, had for 14 hours a succession of hail falls in squalls and thunderstorms, between 29°15′ S., 40½° W., and 30°40′ S., 41° W.; and again in the night of the 21st-22nd, in 34½° S., 49° W., he had heavy showers of hail and of sleet.

On January 13th, 1877, one of our Fellows, Capt. Greenwood, ship *Gareloch*, had a sudden shift of wind from East into South-west, with heavy squalls of large hailstones in 32°53′ S., 29° W.

Capt. Gray's experience in 34° S., 28° W., has already been quoted.

In 31° S., 27½° W., Capt. Stuart, of the ship *Otago*, had a heavy shower of hail on the morning of August 30th, 1873; and at midnight of September 1st, in 32° S., 20° W., Capt. Tully, of the ship *Baroda*, had very heavy hail showers.

On June 12th, 1856, Capt. Tate, of the ship *Meroo*, had heavy hail squalls in 32°55′ S., 17° W.

The log of the barque *Result* shows sharp squalls of hail on August 14th, 1865, in 33°54′ S., 14° W.

On November 24th, 1885, Capt. Russell, of the ship *Khyber*, had frequent heavy hail squalls at intervals of about 20 minutes in 34½° S., 9° W.

Capt. Scougall, of the barque *Closeburn*, had several falls of hail in 34° S., from 1° E. to 3½° E., on September 9th, 1891.

A furious squall from South-west, accompanied by hail, struck the ship *Riversdale*, Capt. Maples, on June 16th, 1875, in 31½° S., 12° E.

On the ship *Amana*, May 15th, 1883, Capt. Becket had heavy squalls of rain and hail between 33¾° S. and 33¼° S., in longitude 15° E.; and on June 27th, 1878, Capt. Ellery, of the ship *Baroda*, had heavy squalls of hail and rain in 32½° S., 16° E., air temperature 51°·9.

I have thus, without exhausting my list, run a line across the South Atlantic from 58° W. to 16° E., but in the Indian Ocean an equally complete chain of short links would be difficult to obtain, owing to the fact that ships follow closely certain well-defined narrow tracks in making for Asiatic ports, and again on their homeward voyages.

About the edge of the Agulhas Bank, off the south-east of Africa, and between 30° S. and 35° S., hail often falls, observers describing the storms as "severe," "violent," "terrific," and so on, the stones frequently being noted as large.

It will be sufficient to give an extract from the log of the barque *Kingdom of Saxony*, Capt. W. C. Smith. At 10 a.m. on July 17th, 1874, in 31°25′ S., 31°50′ E., "there fell a shower of the largest hailstones I have ever seen; not

like ordinary hail, but bits of ice; not of whitish colour, but like glass." Next day, in 30°58′ S., 32° E., there were squalls of very heavy rain and hail.

Further out on the ocean we have Capt. Quirk, of the ship *Mencius*, reporting a severe gale with violent squalls and heavy hail showers, in 31° S., 38° E., on June 27th and 28th, 1856; and a few days later, on July 1st, in 31°40′ S., 41° E., Capt. Liddle, of the barque *Bride*, had very heavy squalls of hail and rain.

Capt. Clement Mossop, of the ship *Candahar*, on April 18th, 1868, was in a heavy southerly gale in 34° S., 74° E., recording squalls of hail and rain.

At 3 a.m. on May 20th, 1856, Capt. Fox, of the ship *Anne Royden*, in 31° S., 81° E., noted, "Squall arose looking very threatening, but instead of much wind it turned into a heavy fall of hail, one flash of lightning, and a clap of thunder. This fall of hail continued three-quarters of an hour."

In 32° S., 96° E., Capt. Fawcett, of the barque *Staghound*, on August 18th, 1877, registered hail squalls in two observations; and on September 3rd, 1875, the ship *Beemah* had violent hail squalls in 32¼° S., 97° E., hail falling nearly all day.

From these records it is fair to conclude that between 30° and 35° S. there is a possibility of meeting with hail all along the ocean from the American to the African, and from the African to the Australian coasts.

Not having handled many Pacific logs entering these limits of latitude, I can only say that the few I have seen strongly support the records in the other oceans, there being records of hail in the South Pacific at different stages between 32° and 34° S., from 152° E. to 95° W., an exceptionally severe hailstorm, extending over 24 hours, being recorded by Captain Price, of the barque *Viola*, on July 22nd and 23rd, 1887, in 33° S., between 106° and 102° W. In corresponding latitudes in the North Pacific the entries seem to be fairly numerous in the western half of the ocean, Capt. Fawcett of the *Staghound*, in February 1878, registering hail eight times in 11 consecutive weather observations between 34° and 35° N., 173° to 180° E.

On the eastern side of this ocean H.M.S. *Satellite*, on August 8th and 9th, 1860, had three entries of hail between 29½° N., 119½° W., and 28¼° N., 118° W., the winds being North-west to North-east light, and the air temperature 66° at 3 p.m., 8th, and noon, 9th, and 65° at 3 p.m., 9th.

Having thus made it perfectly clear, I hope, that we are not warranted in regarding hail as an altogether unusual phenomenon on the sea in the Northern and Southern Hemispheres above the 30th parallels of latitude, I must add the few instances of falls nearer the Equator which have come under my notice. Of course, it will be understood that I have not attempted an exhaustive search of the logs handled, my original intention having been to obtain a general idea of the frequency of hail in the more southern part of the Indian Ocean, the size and distribution being an afterthought when I found frequent mention of storms much nearer the Tropics than the latitude of 40°.

If we think of the influence of the great winter anticyclone over Siberia on the climate of South-eastern Asia we shall all be prepared to find colder weather off the Chinese coast in the early months of the year than is to be met with in similar latitudes in other seas. This influence is strikingly exhibited in the low temperatures, and the snow and hailstorms experienced by ships at some distance from the land between 20° and 30° N.

In a strong North to North-west gale, in about 30° N, 123° E., on February 1st and 2nd, 1862, Capt. Peter Slaughter, of the ship *Spray of the Ocean*, registered 15 consecutive entries of hail, sleet, or snow (8 of hail), the air temperature sinking to 32°.

On February 3rd, 1856, Capt. Quirk encountered a gale in 29¾° N., 124¼° E., with several showers of hail and small snow, the temperature of the air dropping to 41°.

A degree nearer the Equator, in 122° E., on February 26th, 1886, Capt. Pearson, of the s.s. *Strathleven*, had constant showers of mixed hail and rain.

Running down the Formosa Channel for Hong Kong, Capt. Metcalfe, of the White Star liner *Oceanic*, had a succession of hail showers on January 20th and 21st, 1884.

Perhaps it goes against the grain with some, if not all of us, to admit that hail can fall at sea within the Tropics, but I think we have enough data to show that such precipitation is possible.

On April 30th, 1883, in 23° N., 117° E., during a moderate gale, the weather was dull and gloomy, with squalls of hail and very heavy rain, temperature falling from 76° to 73°.

Capt. Dulling, of the s.s. *Port Phillip*, had very dull heavy weather on August 24th, 1885, the sky being overcast with nimbus; temperature at 4 a.m. 83°, 8 a.m. and noon 84°. At 2 p.m. he remarked that the atmosphere was disagreeably sultry, with a nasty haze on the horizon; and at 4 p.m., with nimbus, amount 9, the weather was "oqrh," temperature 78°, the 8 p.m. reading being 84°, and at midnight 83°. The position at 4 p.m. was 20°58′ N., 125°45′ E., a considerable distance south-eastward from the southern extremity of Formosa.

When, however, we go into other parts of the world, where we have totally dissimilar atmospheric conditions prevailing, it may not be so easy to account for hail as it is in the neighbourhood of the China Sea.

Capt. Kerr, of the ship *Ardgowan*, had very heavy squalls of hail and rain on May 24th, 1874, in 29° S, 38½° E.

The P. and O. barque *Indus*, Capt. Lee, was in a violent Southerly gale on May 17th, 1866, and at 10 a.m., in 29°30′ S., 41°38′ E., there were showers of hail in tremendous squalls. At 8 p.m. and 10 p.m. on the 16th the air temperature was 72°, but at 10 a.m. on the 17th the reading was 60°, 2 p.m. 58°·5, 4 p.m. and 6 p.m. 59°·4, and at 8 p.m. 58°; sea temperature changing but slightly—73° to 74° during the day. The gale continuing on the 18th, there was another severe squall with hail at 10 a.m., in 28°58′ S., 40°35′ E., the air temperature being 61°·5. These falls occurred at a distance of about 300 miles from the southern point of Madagascar, and about 500 miles from the African coast.

A remarkable hailstorm was experienced by the barque *Minero* in the South Atlantic on July 6th, 1871. Throughout the preceding night the weather had been very bad, sky heavily clouded, with very heavy thunderstorms and rain. At noon, in 26°27′ S., 39°49′ W., Capt. Carruthers remarked, "After 8 a.m. could see the cum. packed in south-west horizon; overhead covered with cloudy blackness, through which you can see cum. To the west heavy black clouds which passed over about 11 a.m., with excessively heavy thunder and lightning, also hail of extraordinary size, some of it quite half-an-inch square; it was irregular in shape, and the heaviest of it lasted 10 minutes." The temperature of the air was not greatly affected by this fall; it was at 69°·9 on the 5th, at noon, and by 4 a.m. 6th, it was 64°·2, rising to 66°·9 by 8 a.m., falling to 64°·8 at noon, and going up to 67°·9 by 4 p.m. Sea temperature altered very slightly during the two days; 8 a.m. of 6th it was 70°, noon 70°·4, and 4 p.m. 70°·9.

Twenty-two miles inside the Tropic of Capricorn, in 23°6′ S., 36°40′ W., on July 10th, 1855, Capt. Cowell, of the ship *Anna*, entered in his weather column "c hailstones," and stated in the remarks, "At 5.30 p.m. we had a few hailstones, weather very squally, wind from South-west to West." Temperature at 3 p.m. was 71°, and at 6 p.m. 69°. Five days later, as already mentioned, the same ship had several falls of hail between 29° and 30° S.

Approaching still nearer the Equator, my next illustration is found far out in the Indian Ocean, and once more our authority is Capt. Greenwood, F.R.Met.Soc.

On April 14th, 1878, the ship *Gareloch* was on the outer edge of a cyclone, the sky very cloudy, and the wind increasing from the Southward. At 8 p.m., in 21°15′ S., 66°50′ E., with wind South-south-west 5—7 ; air temperature 79° ; cloud form, Str ; amount 10—6 ; and the weather given as "ch," but no comment made in thes pace for Remarks. At midnight, wind South-east 5—8 ; temperature 77°·5 ; cloud, Str, 10—7 ; weather "cbg ;" remark, "Hard squall, wind veering to South-east and East." Were there nothing else to guide us than the bare record for the day, scepticism as to the meaning of the "h" entered as above would be natural, but the log itself is pretty conclusive evidence that the letter was correctly entered for hail, every instance, and there are many of them, of the weather being hazy during the voyage out and home having "m" as its equivalent in the weather column. Even this proof may by some be thought not to determine the point absolutely, for it might be argued that for once the observer had made a slip of the pen. As the case is manifestly a very interesting and important one, I have made assurance doubly sure by an appeal to Capt. Greenwood himself, and he has very kindly gone into the question. The incident having occurred more than 17 years ago, he has not trusted to his memory, for he does not remember it as one of the great events of his life at sea, but he has consulted his private journal for the period, and satisfactorily settles any doubt we may have on the point. He writes to me: "Although there is no entry in the remark column in respect to this incident, I think—nay, indeed, I am sure—that you may accept the entry as a genuine one, and for the following reason :—Throughout my meteorological work I invariably used only the letter "m" for mist or haze, and "h" for hail. In this case the letter is distinctly a capital "H." It was, and is, always my custom to put the letter as a capital in the weather column of my private journal or note book when the phenomenon to which it relates is, what I think, extraordinary. This I evidently thought at the time."

Curiously enough, the remaining tropical records are very much like that of Capt. Greenwood, in that they are not specially commented on in the Remarks.

Capt. McBride, of the ship *Frank Flint*, entered in the weather column at 4 p.m. September 5th, 1875, "gqoHl," the position being 12° 55′ N., 26° 25′ W. The conditions were unsettled, the ship having been under the influence of a cyclone on the previous day, and about the time of the entry in question the wind, which had before been at South and South-west, came out at North, very light, the sky being overcast with cumulo-stratus and nimbus. The log contains several instances of haze represented by "m," and hail by "h," but here the observer gives a heavy capital H.

On February 6th, 1856, the ship *Queen's Hill*, Capt. A. D. Wood, was in a cyclone at the northern extremity of the Mozambique Channel. I cannot do better than present in tabular form the particulars as entered in the log. The position at noon on this date was 10° 29′ S., 43° 28′ E., and at 8 p.m., 10° 59′ S., 43° 42′ E. (p. 239.)

A few days later, on the 9th, Capt. Wood remarks, "These last five days have been excessively disagreeable as regards weather." It will be seen that no reference is made to hail in the remarks, but the general character of the weather points to "h" having been used correctly. In other parts of the log the letter has the recognised signification, and so far as I am able to judge the entry ought to be accepted as a record of hail.

The ship *Seringapatam*, Capt. Carrey, had the weather "opqrth" on May 5th, 1877, in 7°58′ N., 74°17′ E.

Whether these are or are not intended for hail in each particular case, I think we must, on consideration of my final tropical illustration, banish the word "impossible" from our minds. I find Capt. Houston, of the ship *Florence*, giving the following significant facts in his log for May 29th, 1871. At 8 a.m. the ship was 10 miles south of the Equator, in longitude 90°23′ E., with "very heavy rain which was like ice drops." From 4 a.m. to 8 p.m. the temperature of the sea water was 84°, the air temperature being 80° at 4 a.m., 78° at 8 a.m.

Hour.	Wind. Direction.	Wind. Force.	Air Temp. Dry.	Air Temp. Wet.	Cloud—Amount.	Weather.	Remarks.
Noon	N	5	83·4°	78·2°	10	..	Noon—Strong wind with squally appearance. 1 p.m.—In maintop gallant sail and mizzen top sail, and double reefed fore and main topsails. 2 p.m.—A very heavy black squall with deluging rain; obliged to keep dead before it. Remainder blowing very hard with heavy squalls; could not bring the ship by the wind, and abandoned the intention of going to westward of Comoro.
2 p.m.	NNW	6	..	..	..	..	
3 "	WNW	10	77·5	75	..	..	
4 "	W	7	78	..	10	q²R	
6 "	NW	6	77·5	75	..	q	
8 "	NNW	6	79·3	76·2	10	..	
10 "	"	8	80	..	..	hm	
Midt...	"	8	79·2	76	10	..	

and 81° at noon and 4 p.m. When, however, the temperature of the rain water was taken it was found to be 52°, or 32° colder than the sea. There is nothing in the log to show whether the temperature was that of the rain as it fell, or whether it was obtained by collecting a quantity of water in a bucket or some other vessel. In the latter case we can quite understand that a delay of a few minutes would mean a difference of some degrees in the record. Taken as it stands, the observation is one which indicates that we are not to be astonished if some day we unearth a notice of a hailstorm at sea right on the Equator.

As regards the question of polar frequency, Mr. Russell concludes (page 62) that "Hail is almost or quite unknown in the Arctic Regions," and that "Thunderstorms may be said to be equally rare;" and on page 154 we are told that "In the Arctic Regions hail is almost unknown." Now Arctic and Antarctic observations are not so numerous as to justify our arriving at any definite decision. The few logs I have handled for latitudes between 60° and 65° in the Northern and Southern Hemispheres contain a fair sprinkling of hail records, but of Arctic logs I have only chanced to alight on one—the meteorological register kept by Mr. Arnold Pike on the yacht *Siggen* during a northern cruise in 1894.

On May 16th, in 73° N., 18° E., there were showers of snow and hail at 8 a.m. and noon. At noon on the 22nd "a very little soft hail fell;" at 8 p.m. showers of soft hail; next day at 6 p.m. "very fine snow, resembling small hail;" and 8 p.m. ditto, the ship during these two days being between 75½° and 76½° N. 14° and 16° E. Off the southern cape of Spitzbergen at 4.20 a.m. on June 1st, Mr. Pike recorded "snow or ice, like pieces of horsehair, about ¼-in. long, fell for 10 minutes," and from 4 a.m. to 10 p.m. "a very few flakes of snow or ice at times." At 9.15 p.m. on the 3rd, in the same place, he had "slight snow until 11.30 p.m. (like short pieces of hair)." On August 19th, in 72¼° N., 36¼° W., there was distant thunder in east-south-east at 5 p.m., and at midnight there is a remark "distant thunder in south-east all the afternoon. From 10 p.m. to 10.40 p.m. a severe thunderstorm, with rain, passed overhead from south-east to north-west."

Far be it from me to accept this record as deciding that every ship going beyond the latitude of 70° must necessarily experience hail and heavy thunderstorms, I merely give the facts to show that the phenomena are at least not "quite unknown"—an occasional visitor can prove nothing more.

I have now shown that hail is possible at sea in all latitudes as far as ships go north and south of the Equator, and that over wide belts on the polar side of the 35th parallel it is familiar to seamen. What we want next is a theory which can be reconciled with the abundant testimony available.

NOTE.—JUNE 19TH, 1895.

Since this communication was placed in the list of Papers for discussion at this Meeting, I have consulted the following publications containing information bearing upon the question of hail at sea:—

(1.) *Remarks explanatory of the Charts of Meteorological Data for the Ocean District adjacent to the Cape of Good Hope*, Official No. 43, published by the authority of the Meteorological Council. Appendix II., pp. 73-84, gives, in tabular form, the frequency of the various weather elements, clouds, &c., in spaces of 5° of latitude by 10° of longitude for each month of the year. There are a number of instances of hail forming from 10 to 31 per cent. of the weather observations.

(2.) *Die Aequatorialgrenze des Schneefalls*, a paper by Herr Hans Fischer, in the Leipzig *Mittheilungen des Vereins für Erdkunde* for 1887, pp. 99-274. This is a discussion of the equatorial limits of snow on land and sea, but Herr Fischer has included a large number of hail records in the extracts he gives from the meteorological logs at the Deutsche Seewarte and from other sources. They are tabulated separately for each ocean for the winter months, and in the main confirm the results arrived at in this paper. In the North Atlantic he gives hail down to latitude 32° N., in the North Pacific to 31° N., in the South Atlantic up to 34½° S., and in the Indian Ocean to 33° S.

(3.) *Waarnemingen in den Indischen Ocean*, Koninklijk Nederlandsch Meteorologisch Instituut, Utrecht. This publication is to consist of four volumes of charts showing, for the Indian Ocean, the results obtained from a discussion of various meteorological data, the two volumes representing respectively the months December to February and March to May having already been issued. One chart is devoted to hail percentages, and from this it is evident that over such a long period as three months there are portions of this open ocean, far removed from land, where hail forms 25 per cent. and upwards of the weather records.

Having given only one reference to North Polar observations, it may be of interest to add another for the Antarctic regions. In the log of H.M.S. *Terror* I find several entries of hail beyond the 60th parallel to within 16° of the South Pole, or nearly to the most southern point reached by Sir James Ross. Hail was experienced on January 21st, 1841, in 74° 12′ S. 170° 45′ E., and on February 25th, 1842, in 74° 12′ S. 167° W.—H. H.

DISCUSSION.

The Hon. F. A. R. Russell said:—In the first place I wish to express the pleasure with which I have heard the paper which has just been read. It deals with a subject on which hitherto very little light has fallen from authentic sources, and certainly no such maritime records as have been quoted were within my knowledge when I wrote my book *On Hail.* Now it appears that mariners have for more than 40 years been registering systematic observations for the Meteorological Office, and that several thousands of logs, some of which make mention of a phenomenon such as hail, are stored in Victoria Street. These logs must contain many treasures, and one can only rejoice when, as we have seen to-night, these "gems of purest ray serene" are brought to the surface and set in the sunshine of our Society.

Before proceeding to discuss Mr. Harries' paper, it may be well to distinguish —for perhaps I have not sufficiently done so in my book—between large and small hail. It was the large or summer hail with which I dealt; disregarding the small hail, graupel, or sleet, of cool climates or seasons. Mr. Scott, in his *Elementary Meteorology*, says, "Soft hail falls chiefly in winter and spring. True hail is a very different thing. It is usually composed of concentric layers of hard and soft ice," &c. . . "In these islands, fortunately, we know but little of destructive hailstorms. On the Continent we are almost everywhere met by the frequent advertisements of Hail Insurance Offices, which are comparatively rare here. This immunity of ours is due to our insular climate, and its consequent freedom from extremes of temperature."

Only two instances, Mr. Harries states, are given in my book of a hailstorm on the water, and he then infers that since the extracts cover a period of more than two centuries, it is not surprising that I should have decided that "in mid-ocean it is almost unknown." Yet I know well that many great hailstorms might occur at sea, while an accurate description of one of them might still be wanting. Further, when referring to my "Summary of Characteristics of Hail-storms and Hailstones," he quotes me as having written "in mid-ocean it [hail] is almost unknown." The actual words are different: "In mid-ocean it is uncommon," the previous sentence being, "In the Arctic regions hail is almost unknown," so that a distinction is clearly drawn between "almost unknown" and "uncommon." Then he speaks of the upshot of theories and conjectures discussed in the book resolving itself into a *law* which declares (p. 202) that "the equability of the ocean temperature and the usual absence of comparatively very cold masses of air at a high level will rarely allow the development of great hailstorms over the open sea." I have said nothing of law. This is an opinion, and I am inclined to defend it.

To show that the subject which I treated of was large hail, I would ask the Fellows to observe that in a large number of cases of hailstorms described the measurements of hailstones are given. In going through these accounts, I find that in 58 out of a total of 61 hailstorms noted in the first chapter, there is clear testimony to the hail being of very large size, such as nuts, walnuts, eggs, apples, oranges, and up to 12 inches in circumference. On the other hand, the great majority of the data extracted from logs in this paper seem to be reports of small hail. When one observer gives 116 records of hail while running about two-thirds round the southern hemisphere, we can hardly suppose that anything but either small hail or sleet is referred to, else the deck would have been cleared of its crew. The hail at Kerguelen on 24 days out of 70 fell in May and June, the beginning of winter or end of autumn. For my part I should never think of doubting that small hail may be very common in mid-ocean, both in the northern and southern temperate zone. I have myself experienced dense hail-storms in the extreme north of Scotland in September, but have not mentioned this in my book.

Further on, Mr. Harries adds to his previous misquotation by attributing to me the theory that hail at sea "is almost unknown," where "almost unknown" should be "uncommon," and "at sea" should be "in mid-ocean." His contention, however, is perfectly clear, and no doubt at variance with the belief expressed in my book, for he says that "great hailstorms are often met with on the open ocean." He then gives a number of examples of great hailstorms

during a period from 1857 to 1891. Twelve of the twenty-two mentioned were great hailstorms within my meaning of the term. But were these twelve "in mid-ocean"? No. 1 (Capt. Jeffery) certainly was in mid-Atlantic. The only indication of the size of the hailstones is the word "immense." No. 2 (Capt. Peebles) occurred apparently about 300 or 400 miles from the African continent, which I should hardly describe as mid-ocean. I pass by the *Shun Lee* observation, for though it was in mid-Atlantic, the hailstones were only as big as large peas. No. 3 (Capt. Gray) was very near Cape Horn, and No. 4 (Capt. Gray) apparently within about 200 miles of land. No. 5, in 42° S. 60° W., was about the same distance from land. No. 6 (Capt. McRitchie) was apparently about 200 miles from land. No. 6A (Capt. McRitchie) was a good instance, say 1,000 miles from land. No. 7 (Capt. Gales) was close to Cape Horn, and the same remark applies to the next observation made by his brother near the same position, an interesting note of "large snowballs" in October. No. 8 (Capt. Kerr) was apparently 100 or 200 miles from the Cape of Good Hope, a fall of pieces of ice of great size, about 2 inches square, accompanying a waterspout and a terrible flash of lightning. No. 9 (Capt. Wight) was in a similar position. No. 10 (Capt. Wilson) was in mid-ocean, but the splinters of ice were only half-an-inch in length. No. 11, in the Bay of Biscay, was apparently about 150 miles from the coast of Brittany. The distances from land above given are merely from rough measurements on a chart, but I hope not very far wrong. The only other hailstorms of a severe character, as regards the size of hailstones, mentioned in the remainder of Mr. Harries' paper, are one observed by Capt. W. C. Smith, close to the coast of Natal, and one by Capt. Carruthers, about 400 miles from the South American coast. In this case the hail is described as of an "extraordinary size," but the largest seems to have measured no more than "half-an-inch square."

Thus we have finally a record in this paper of 14 hailstorms at sea, which by the test I have mentioned might be described as great. Of these, only four seem to have been more than about 300 miles from land, and only three more than about 400 miles from land. These three are Capt. Jeffery's of March 14th, 1883, in 41° N. 43° W.; Capt. Wilson's (pieces of ice like splinters ½ in. in length), in 41° S. 49° E.; and Capt. McRitchie's ("hailstones as large as marbles"), in 38° S. 2° E. Thus no record remains of hailstones in mid-ocean, or more than 500 miles from a continent, in which the hailstones were more than ½ in. long. And I have seen no account of great hailstones of such a size on any of the small non-mountainous islands lying in the vast central areas of the ocean. On the other hand, in the 61 instances I have given of storms on land, the *average* size of the hailstones would be about 1½ in. in diameter; many were over 2, and some over 3 ins.

The influence of a continent is certainly considerable within 500 miles distance on the ocean: firstly, by reason of the masses of heated or cooled air which may be transported so far in a single day; and secondly, perhaps principally, in relation to hail, by reason of their deflecting great ocean-currents so as to bring warm and cold waters alongside each other. Southernmost Africa has the effect of bringing the equatorial and polar currents into proximity within a few hundred miles south of the land, and it is not surprising that the resulting differences of neighbouring air masses should give rise to storms. Similarly, the dense fogs off the coast of Newfoundland and a long way out to sea are produced by the deflection of an Arctic current so as to flow along the borders of the warm current from the south.

Mr. Harries has proved in this paper that hail has often been encountered at sea, and especially that certain large areas, such as the tract of ocean south and south-east of the Cape of Good Hope, are subject to great hailstorms, and I fully admit that he has shown these to be more prevalent than I had supposed, and acknowledge the value of this interesting contribution.

Capt. M. W. C. Hepworth said:—Being one of those who for years have been keeping some of those "gems," as Mr. Russell has satirically termed them, I wish to say that we who have been keeping these Meteorological Logs have been under the impression that we were materially aiding in the good cause. The wind and current charts I would remind Mr. Russell were drafted from logs kept by seamen. Hail is by no means an uncommon occurrence at sea, and even in the tropics I have seen it more than once.

During a thunderstorm in the Red Sea, when the Telegraph Steamer *Hibernia* was laying the duplicate Bombay Cable in 1876, hail fell. In a private abstract log of mine observations of weather are recorded daily for noon at sea for many past years.

Rain, hail and snow occur less frequently at sea at about noon than at any other period during the 24 hours, so that although my records do not support Mr. Harries' contention as regards the frequency of hail at sea, the position in which they were recorded may be considered, and as bearing upon the subject.

By referring to my abstract I find that in 1,526 days at sea hail was recorded at noon 21 times. My abstract is of voyages made to many parts of the world; but I should mention that 13 passages were to Australia *viâ* the Cape of Good Hope, and that 12 of the return passages were made *viâ* the Suez Canal, and one *viâ* Cape Horn. Other voyages were to India, China, Japan, the Straits Settlements, America, and other parts.

Out of 21 h's that I find recorded at noon, 14 are in the South Indian Ocean between Cape Point and 46° S., three in the South Pacific Ocean, between New Zealand and 57° S.—on the only passage home made that way,—and four in the North Atlantic between Ushant and 40° N. The 17 cases of hail at noon recorded in the Southern Oceans occurred either in the trough, or immediately in rear of the trough of systems of low pressure.

Hail-squalls are common enough on the North Atlantic on the "Ash Tracks" —if I may use a sailor's expression—between England and America. I can vouch for that.

Mr. H. Harries, in reply, said that in quoting from page 154 of *On Hail*, he had inadvertently taken "almost unknown" from one line instead of "uncommon" in the next. The correction, however, introduces no difficulty, for it is now shown that hail is one of the most common of the phenomena recorded in many parts of the open ocean. With regard to Mr. Russell's view that we should take the expression "mid-ocean" in its narrowest sense, it is sufficient to say that ships usually follow certain well-known tracks, and it is only by chance that the centre of any particular ocean is visited: see page 8 of the *Report of the Meteorological Council* for the year ending March 31st, 1889, where it is stated that "the anticyclonic regions of the great oceans, . . . characterised by calms and light winds, are practically avoided by navigators." Then as to the suggestion that great hailstorms should be considered as storms in which the hailstones are very large, he (Mr. Harries) doubted very much whether anyone would support that view. Many English and Continental hailstorms are very severe and very destructive, and yet the stones are of the most ordinary size. The violent storm which burst over Vienna and other parts of Austria a year ago does not appear to have been remarkable for the size of the stones which fell, but it certainly was a very great hailstorm for all that, the gauges registering from 1 in. to 1¾ in. of water in little more than half-an-hour. The 2 ins. of hail in a few minutes noted by Capt. Gray, and the 3 ins. in 20 minutes by Capt. Holdich, nearly 1,200 miles from the Brazilian and New Zealand coasts respectively, would have been considered perfect avalanches had they occurred anywhere on land. There is no necessity to enter into details as to ships and dates, but the logs show that tremendous falls of hail, large hail noted in many cases, occur in the North Atlantic between 25° and 40° W., in the South Atlantic between 10° and 30° W., in the Indian Ocean between 50° an 100° E., in the South Pacific between 90° and 160° W., and in the North Pacific about the longitude of 180°, in positions which are from 1,000 to 2,000 miles from the nearest Continental land. Reference is made in the paper to a ship recording hail 96 times in crossing the Indian Ocean. The log shows the heaviest fall, the entry being underlined three times, to have been during violent squalls in 43° S. 52° E., or about 1,300 miles from the African coast. What would appear, from the similarity of the records, to have been a hailstorm of immense area was experienced by two vessels during a heavy Westerly gale in mid-ocean in July 1877. The ship *Taranaki* had excessively violent squalls of hail and rain at 4 p.m. on the 1st in 41½° S. 56½° E., and out of 21 weather entries down to midnight of the 4th, in 40¼° S. 77° E., a run of 950 miles, hail was registered 14 times. The ship *Pomona* ran into the heavy hail squalls at 4 a.m. on the 2nd, in 46¾° S. 71° E., and out of 24 weather entries down to midnight of the 5th, in 47¾° S. 96¼° E., a run of 1 000 miles, hail

was registered 15 times. The heaviest part of this hailstorm was at about 2,000 miles from the African and Australian coasts respectively. It will be seen that the points at which the vessels first encountered the hail were 700 miles apart, and the points at which the hail ceased 900 miles apart. It might be of interest to note that while on land the tendency is for hailstorms to occur in the afternoon or evening, the evidence in the logs shows that at sea, where the daily range of temperature is comparatively very small, they seem to be fairly distributed over the 24 hours, often with and often without thunder and lightning. We sometimes read of rain from a cloudless sky; but in the course of this inquiry he (Mr. Harries) had only noticed one instance of hail under similar conditions. In September 1883, in 51¼° S. 63½° W., the barque *Caldbeck* had a succession of heavy hail squalls for about eight hours, the cloud-form being "cum," amount 2, weather "b h," three entries of each, the observer remarking that the "cum" was on the horizon, the sky aloft being clear. Capt. Hepworth has mentioned a fall of hail in the Red Sea, but the log of the ss. *Hibernia* for November 16th, 1876, while it describes a severe thunderstorm with vivid forked lightning and very heavy rain between 9.30 and 10.30 a.m. in 21° N. 38° E., does not make any mention of hail. There was, however, a sharp drop in the shade temperature—8 a.m. 88°·5; noon, 83°·2; 4 p.m. 86°·5.

Capt. D. Wilson-Barker wrote that he had not been struck by any apparent difference between the amount or frequency of hail at sea and on land. He sent the following extract from a letter he had received from Capt. D. Morton, of the Telegraph Ship *Dacia*, June 14th, 1895:—"On February 5th last, while repairing the Spanish National Cable, we had to seek shelter in the Port of Mazighan,[1] in lat. 33°15′·6″ N. long. 8°26′·6″ W. On the morning of the 6th, about 10.30 a.m., we experienced a heavy fall of hail, which lasted for about 10 minutes, the hailstones being the largest I have ever seen, being about the size of marbles. The barometer on board at this time stood at 29·515 ins., dry-bulb 57°·5, wet-bulb 57°, wind fresh from West. The fact that such a thing was unknown in this port at any former time may make it interesting."

Admiral J. P. Maclear, who was unable to remain for the discussion, wrote that he had examined the *Challenger* observations during her 3½ years' cruise, and found six entries of hail, viz. January 27th, 1873, 60 miles west of Gibraltar: 3 p.m., hail squall from West-north-west; May 15th, 1873, at Halifax: "h" recorded one hour; January 5th, 1874, lat. 48° S., long. 62° E.: 10½ p.m., heavy hail squall, during which wind shifted to South-south-east; January 22nd, 1874, at Kerguelen island: 1.30 a.m., a sharp hail shower; January 25th, 1876, at Port Stanley, Falklands: "h" recorded one hour; February 10th, 1876, lat. 44° S., long. 56° W.: 0.30 a.m., a hail squall, 7.30 p.m., heavy squall with hail.

[1] Coast of Morocco.

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

May 15th, 1895.

Ordinary Meeting.

RICHARD INWARDS, F.R.A.S., President, in the Chair.

Lt.-Col. HARLOVEN MORLEY SAUNDERS, Oakfield, The Park, Cheltenham, was balloted for and duly elected a Fellow of the Society.

The following communications were read:—

"THE NOVEMBER FLOODS OF 1894 IN THE THAMES VALLEY." By G. J. SYMONS, F.R.S., and G. CHATTERTON, M.A., M.Inst.C.E. (p. 189.)

"BAROMETRICAL CHANGES PRECEDING AND ACCOMPANYING THE HEAVY RAINFALL OF NOVEMBER, 1894." By F. J. BRODIE, F.R.Met.Soc. (p. 209.)

"A NATURAL THERMOMETER." By Rev. FENWICK W. STOW, M.A., F.R.Met.Soc. (p. 214.)

June 19th, 1895.

Ordinary Meeting.

RICHARD INWARDS, F.R.A.S., President, in the Chair.

STRATTON COLLINGS KNOTT, H.B.M. Vice-Consul, Mojanga, Madagascar; and ROLAND PILLINGS, F.R.A.S., Secretary, Meteorological Commission, Cape Town, were balloted for and duly elected Fellows of the Society.

The following communications were read:—

"HOURLY VARIATION OF SUNSHINE AT SEVEN STATIONS IN THE BRITISH ISLES." By RICHARD H. CURTIS, F.R.Met.Soc. (p. 216.)

"THE FREQUENCY, SIZE, AND DISTRIBUTION OF HAIL AT SEA." By HENRY HARRIES, F.R.Met.Soc. (p. 230.)

CORRESPONDENCE AND NOTES.

Weather Bureau, Washington.—Prof. Mark W. Harrington has retired from the post of Chief of the U.S. Weather Bureau, and Prof. Willis L. Moore has been appointed as his successor.

Prof. Moore entered the Signal Service School at Fort Myer in 1876, and ranked second in a graduating class of thirty members. In 1886 he was made a Sergeant on account of his having devised certain improved methods of issuing the daily weather forecasts and maps. After being stationed at Chicago, Ill., and Albany, N.Y., Prof. Moore was transferred to the Central Office in Washington, where he remained till 1891. In that year he was transferred to Minneapolis, Minn., and later to Milwaukee, Wis., at which places he was Local Forecast Official and Director of the State Weather Services. During the past year Prof. Moore entered the competitive examination for a professorship in the Weather Bureau, and attained the highest rank among the ten candidates who had stood best in the examination, and were therefore selected to compete in practical forecasting. His attainment of this rank gave him the professorship. Since his appointment as professor, the present Chief of the Weather Bureau has been Local Forecast Official at Chicago, Ill., where during the past winter he made a very fine record in his cold wave forecasts.—*American Meteorological Journal.*

The Sonnblick Observatory.—A general meeting of the Sonnblick Verein was held on April 6th. The President, Colonel Edler von Obermayer, was able to report an increase in the number of members, but urged the necessity of obtaining still wider support in the future. A paper on the scientific results of the Sonnblick observations up to the present time was read by Dr. W. Trabert. First must be placed the startling result reached by Hann, chiefly from a discussion of the Sonnblick observations, that the central column of air in a cyclonic system does not ascend by reason of relatively higher temperature, being in fact, colder than the air surrounding it; nor does the air in the descending current of an anti-cyclone attain its greater relative density by reason of lower temperature. This conclusion produced almost a revolution in the domain of dynamical meteorology, as it was practically a death-blow to what was known as the convectional theory of cyclones. Dr. Trabert gave an account of some researches made by himself on the warming of the air by direct absorption of the sun's heat at a mountain summit. The results which have already been published in full, show that, as at lower levels, the air is chiefly warmed by convection from the earth's surface. Hann has further succeeded in estimating the daily range of temperature in the free air not affected by ascending and descending currents from mountains—an investigation which was always supposed to involve observations from balloons. In a zone such as that between the summits of the Sonnblick and Mont Blanc, the daily range was found to amount to only 1°C. Hann further points out than the Sonnblick observations agree with those of other mountain stations in throwing considerable doubt on modern theories explaining variations of wind velocity. Investigations more in the domain of pure physics have been made by Elster and Geitel, on the nature of St. Elmo's fire, the atmospheric absorption of the ultra-violet rays, etc. Trabert and Pernter are at present engaged in an extensive work dealing with the general geographical relations of the results just enumerated.—*The Geographical Journal.*

A High-Level Observatory in Tasmania.—In May last Mr. Clement L. Wragge induced the Government of Tasmania to establish a meteorological observatory on Mount Wellington, four miles in a straight line from Hobart. At the Springs, 2,495 feet above sea level, Constable Gadd's quarters were fixed on as a half-way observatory, and thermometers and a barometer will shortly be placed there. Later on a barograph, thermograph, and hydrograph will be set

up at the Springs. When the party arrived at the summit, 4,166 feet above sea-level, a cairn already commenced to protect the instruments on a pile of jagged rock, 150 yards west of the pinnacle, was completed. Here the instruments were placed, most of them self-registering, and of the latest and most approved types, an enlarged Stevenson screen being used for the thermometers, as at Hobart and the Springs. In the meantime they will be read once a week, but a permanent observatory is in course of erection, and, when it is finished, observations will be recorded daily. The thermometer on the summit marked 42° at 3 p.m. Mr. Wragge was assisted in carrying up the instruments by Mr. Kingsmill, of the Hobart Observatory, and by Captain Balfour, of the *Penguin*, who placed six sailors at his disposal.—*Scottish Geographical Magazine.*

Fogs in the North Atlantic.—In the *Pilot Chart* for July the U.S. Hydrographic Office gives twelve monthly charts, which represent graphically the regions where fog was experienced most frequently on the North Atlantic during 1894, as shown by reports from the voluntary observers of the Hydrographic Office. This year can be taken as a typical one to illustrate the fog areas at the different seasons. During January, February, and March, fog is experienced on the Great Banks, and to the westward, but not in large quantities. During April it begins to extend to the northward and eastward, increasing in frequency as the spring advances, and reaching its maximum generally in June or July, during which months it may be expected anywhere between the American coast and the British Isles in large areas and of long duration. In August the fog begins to dissipate in the eastern part of the ocean, and in September the decrease is very perceptible. During the remaining three months it falls to the minimum again.

RECENT PUBLICATIONS.

American Meteorological Journal. June-August 1895. 8vo.

The principal articles are:—The Thermophone: by H. E. Warren and G. C. Whipple (16 pp.). This is a description of a new instrument for obtaining the temperature of a distant or inaccessible place. The authors also give an account of some observations which have been made with the instrument on the temperature of surface waters.—California electrical storms: by J. D. Parker (5 pp.).—The Augusta, Ga.. tornado of March 20th, 1895: by W. J. Wambaugh (6 pp.).—Psychic effects of the weather: by C. A. Beals (7 pp.).—The geographical distribution of the maximum and minimum hourly wind velocities, and their relations to the average daily wind velocities for January and July, for the United States: by Dr. F. Waldo (15 pp.).—Relation of clouds to rainfall: by H. H. Clayton (7 pp.). During 1887 and 1888 hourly cloud observations were taken at the Blue Hill Observatory, with but few omissions, for 16 hours of each day between 7 a.m. and 11 p.m. From an analysis of these observations the author is of opinion that cloud forms cannot in general be used in predicting rain for an interval exceeding 24 hours, but for a few hours in advance the existence of certain cloud forms frequently furnish the individual observer more reliable indications of the coming rain than does the weather map. If the detailed cloud forms, the pressure, wind, cloud movements, humidity, &c., were considered, the forecasting value of the clouds would no doubt be considerably increased.—The meteorograph for the Harvard Observatory on El Misti, Peru: by S. P. Fergusson (4 pp.). As it is impossible to maintain observers on the summit of El Misti, which is 19,300 feet above sea-level, this special self-recording instrument has been devised for use on the mountain. The clock is intended to run for four months without re-winding, and one year's supply of paper can be placed upon the rolls at one time.—Electrical phenomena in a dust storm: by F. P. Gulliver (5 pp.).

Annuaire de la Société Météorologique de France. December 1894-January 1895. 4to.

Contains:—Distribution annuelle des orages à la surface du globe terrestre: par A. Klossovsky (4 pp.).—Sur l'aurore boréale du 13 novembre 1894: par A. Angot (2 pp.).—Notes sur la photographie des Nuages: par A. Angot (5 pp.).—De la durée de le pluie en heures au Parc Saint Maur et à Perpignan: par P. Cœurdevache (4 pp.).—Variation diurne de la fréquence de la pluie: par P. Cœurdevache (2 pp.).—Eclairs du 19 décembre 1894: par M. Tardy (2 pp.).—Les orages à Montdidier (Somme), d'après les Drs. Chandon: par V. Raulin (8 pp.).—Sur la diminution progressive des pluies dans le Calvados: par G. Guilbert (3 pp.).

British Rainfall, 1894. Compiled by G. J. Symons, F.R.S., and H. Sowerby Wallis. 8vo. 1895.

This work increases in value year by year. It was started in 1860 with records from 168 stations. The present volume for 1894 contains records from 3,043 stations. Notwithstanding this large increase, more stations are required in Scotland, and especially in Ireland.

The total rainfall over the British Isles for 1894 was about 6 per cent. above the average. The greatest rainfall was 166·22 ins. at The Stye, Cumberland, and the least 18·56 ins. at Leicester. The heaviest fall in one day was 7·74 ins. at Ben Nevis Observatory on February 6th.

In addition to the usual information on the rainfall for the year, the volume contains articles upon various branches of rainfall work, among which may be mentioned "The Dryness of years ending with 4," and "The October and November Floods."

Journal and Proceedings of the Royal Society of New South Wales. Vol. XXVIII. 1894. 8vo.

Contains the following articles on meteorological subjects:—An Essay on Southerly Bursters: by H. A. Hunt (48 pp.).—Current Papers: by H. C. Russell, F.R.S. (12 pp.).—A Map, showing the average Monthly Rainfall in New South Wales: by H. C. Russell, F.R.S. (3 pp.).—On a new Velocity Recorder and its application to Anemometry and other purposes: by J. A. Griffiths (9 pp.).

Meteorologische Zeitschrift. Redigirt von Dr. J. Hann und Dr. G. Hellmann. May and June 1895. 4to.

The principal articles are:—Wolkenbildung durch das Nordlicht: von Dr. A. Paulsen (9 pp.). The author cites numerous utterences of older writers like Bravais and Weyprecht on the analogies between auroras and certain cloud forms. It is well known to most observers that cirrus cloud occasionally appears just like the rays of an aurora, and Dr. Paulsen quotes reports from Dr. Hildebrandsson of luminous clouds which appear and disappear suddenly: and he endeavours to prove that all the clouds which resemble auroras are really only ordinary clouds of water or ice dust, which owe their existence to the auroral discharge, and are illuminated by it. It is a known fact that the discharge from a cathode, when absorbed in the atmosphere, generates ozone freely, and this condenses aqueous vapour. If we imagine an aurora immoveable, it would envelope itself in a cloud, and accordingly Weyprecht's statement that auroras which are indistinct have no action on the magnetic needle appears well founded. The aurora, according to Dr. Paulsen, is closely similar to the cathode discharge.—Ueber die Ermittlung der Temperatur und Feuchtigkeits-Unterschiede zwischen Wald und Feld: von E. Ebermayer (6 pp.). This is an interesting account of observations carried out by means of Assmann's aspirator at Eberswalde. These show very much lower differences between the forest and the clearances than resulted from the ordinary thermometer screen. But Dr. Ebermayer goes on to show that this result is mainly due to the type of screen in use in North Germany, and that the results obtained from the mode of exposure in Bavaria agree very closely with those obtained by the aspirating apparatus.—Der Föhn vom 13 Januar 1895 am Nordfuss der Alpen und die Bildung einer Theildepres-

sion daselbst: von R. Billwiller (9 pp.). This is an interesting account of the appearance of the föhn in Switzerland in the middle of January. Dr. Billwiller describes the conditions prevailing over Central Europe during the frost of the first part of January, and shows how the appearance of a depression off the West of Ireland gradually made its influence felt as far as Switzerland, and drew the air over the Alps. The föhn appeared first at the lowest pass of the St. Gothard, and subsequently at others, following according to their altitude. According to the author, the föhn distinctly gave rise to a secondary depression over Switzerland, whereas M. Hébert, in his paper on the föhn and sirocco, states that the local depression produced the föhn.

Sitzungsberichte der kaiserlichen Akademie der Wissenschaften in Wien. Band CIV. Abth. II. April 1895. 8vo.

Contains a paper by Dr. Hann, "Die Verhältnisse der Luftfeuchtigkeit auf dem Sonnblickgipfel" (51 pp.). This is an analysis of the records of a Richard hydrograph, which has been in use at the observatory on the Sonnblick since September 1893, so that two full winters have been available for the discussion. Dr. Hann expresses himself as thoroughly satisfied with the performance of the Richard instrument, having compared it carefully with Koppe's hair hygrometer, and with the dry and wet bulb psychrometer. He points out that as a rule at mountain stations the annual course of relative humidity is the opposite to that which prevails at low level stations, for the minimum falls in winter and the maximum in summer. The author gives tables of the diurnal range of the relative humidity in the different months and its relation to sunshine, and to clear and cloudy days respectively, and concludes the paper with a discussion of the phenomena observed during periods of great dryness.

Symons's Monthly Meteorological Magazine. June-September 1895. 8vo.

The principal articles are:—Rainfall Observations in China, 1886-92: by M. le Prof. Raulin (3 pp.). The author has summarised the observations collected and published by Dr. Doberck, of the Hongkong Observatory. The mean annual rainfall is small in the North, and increases greatly towards the South. From about 20 inches in the Gulf of Pe-chi-li it becomes double that in the Delta of the Yang-Tse-Kaing, and going about 500 miles up the river it is 58 inches at Hankow. Continuing along the coast it is about 45 inches, but reaches 68 inches at Ningpo. At Canton it is 66 inches, in the north of the island of Hainan 54 inches, in Formosa it ranges from 60 to 90 inches; but at Keelung the north-east point it reaches 148 inches.—Earth Temperature and Water Pipes (2 pp.).—The Dryness of the first half of 1895 (3 pp.). It appears that the greatest deficiency of rainfall was slightly to the north-east of London.—Indelible Degree Marks on Thermometers (2 pp.). This describes an invention recently brought out by Mr. J. J. Hicks for securing an imperishable scale for thermometers.—The Rainfall of Belgium (4 pp.).—Aqueous Vapour and Temperature: by J. R. Sutton (3 pp.).—The Yorkshire Whirlwind of August 10th (5 pp.).—Temperature of European Rivers: by H. N. Dickson (2 pp.).

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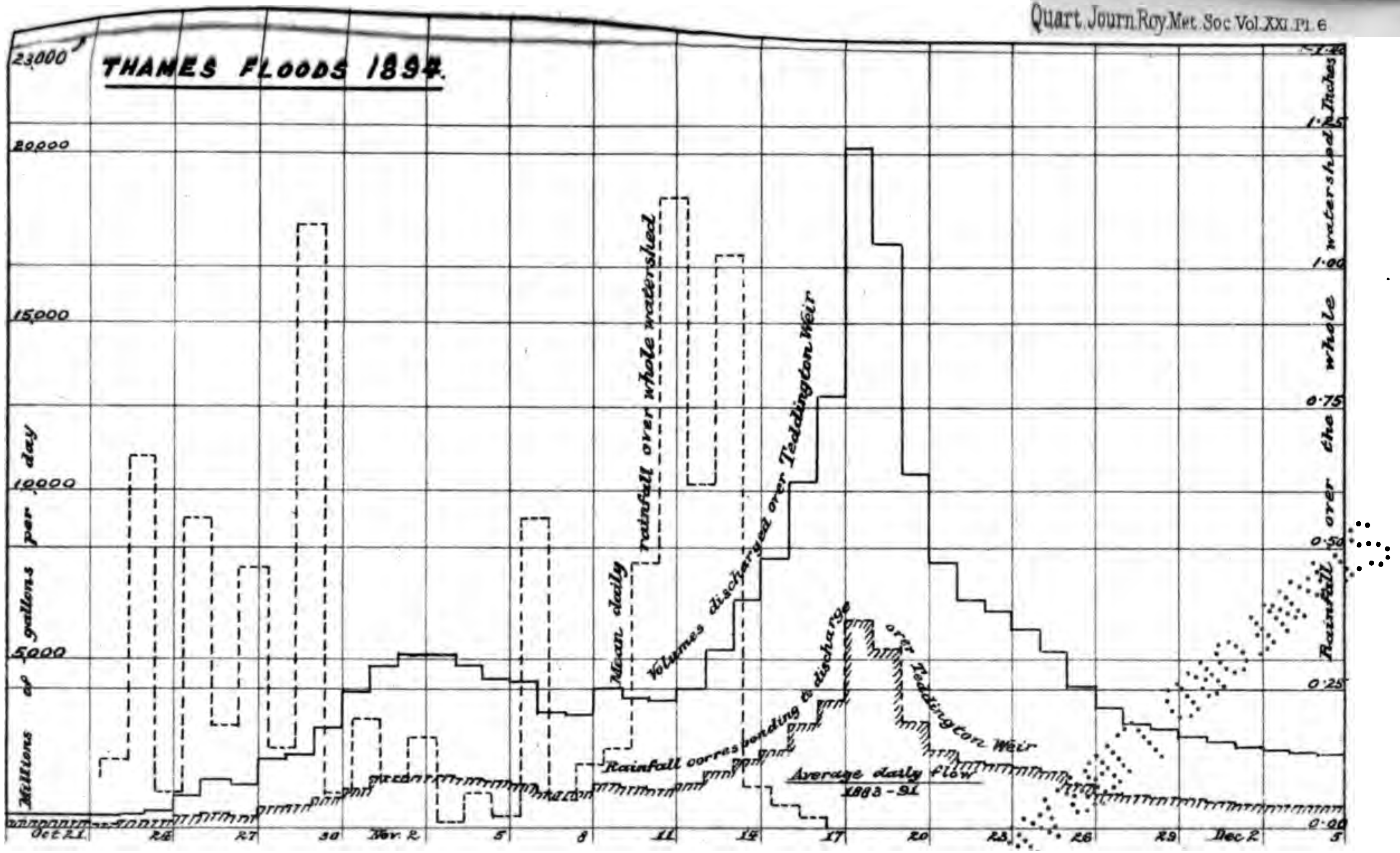
THE END.


THAMES FLOODS 1894.
23000
20000
15000
10000
5000
Millions of gallons per day
Rainfall over the whole watershed Inches
1·25
1·00
0·75
0·50
0·25
0·00
Mean daily rainfall over whole watershed
Volumes discharged over Teddington Weir
Rainfall corresponding to discharge over Teddington Weir
Average daily flow 1883 - 91
Oct 21
24
27
30
Nov. 2
5
8
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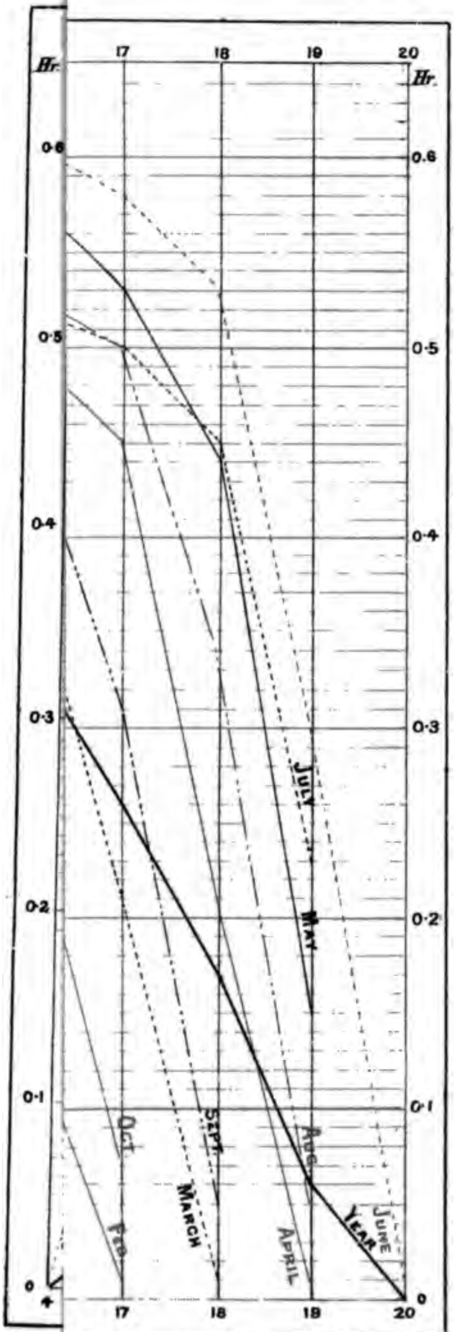

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